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Performance of Ozone/Fenton in the Advanced Oxidation Process of Semi-Aerobic Landfill Leachate

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Abstract:

Leachate pollution is one of the main problems in landfilling, and researchers have yet to find an effective solution to this problem. The technology that can be used may differ based on the type of leachate produced. In Malaysia, the most problematic pollutants in semi-aerobic (stabilized) leachate are chemical oxygen demand (COD), ammoniacal nitrogen, and color. In the present study, the performance of ozone/Fenton in advanced oxidation process in removing these pollutants was investigated. The optimal dosages of Fenton reagent (0.05 mol L-1 (1,700 mg/L) H2O2 and 0.05 mol L-1 (2,800 mg/L) Fe2+) were determined through preliminary experiments and added to the leachate sample into the ozone reactor. The input ozone concentration in a 2 L leachate sample was 80 g/m3NTP ± 0.5% under 1 bar pressure. The initial COD varied between 250 and 2360 mg/L, color varied between 470 Pt. Co. to 4530 Pt. Co., and NH3-N varied between 150 mg/L to 1170 mg/L. Accordingly, the maximum removal efficiency was 87% for COD, 100% for color, and 22% for NH3-N at lowest leachate concentration. The lowest amount of consumed ozone (1.28 KgO3/ Kg COD) corresponds to the initial concentration of COD (2000 mg/L) with 60% removal of COD during 1 h ozonation. Moreover, the biodegradability (BOD5/COD) ratio improved from 0.09 in raw leachate to 0.27 at 500 mg/L initial COD. The current study revealed that the use of ozone/Fenton (O3/H2O2/Fe2+) in advanced oxidation process is more efficient in removing COD and color in low concentrations of semi-aerobic stabilized leachate and in improving biodegradability.

Keywords: Ozonation, Advanced oxidation, Initial concentration, Stabilized leachate, Biodegradability

1. Introduction

Sanitary landfilling is the most common and desirable method for controlling urban solid waste. It is also considered the most economical and environmentally acceptable method for eliminating and disposing municipal and industrial solid wastes (Tengrui et al., 2007). However, sanitary landfills are also prone to polluting the immediate environment. Landfill leachate is the liquid that has seeped through solid waste in a landfill, gaining extracted, dissolved, or suspended materials in the process (Christensen et al., 2001). Landfill leachate is a potentially polluting liquid unless returned to the environment in a carefully controlled manner (Scottish Environment Protection Agency, (SEPA, 2003). Leachate contains high amounts of organic compounds, ammonia, heavy metals, a complex variety of materials, and other hazardous chemicals, and is recognized as a potential source of ground and surface water contamination (Schrab et al., 1993; Christensen et al., 2001; (SEPA), 2003).

One of the main problems with landfill management is the establishment of efficient treatments for large quantities of polluted leachate. Ozone has recently received much attention in landfill leachate treatment technology due to its powerful chemical oxidant and high capacity for oxidation (Huang et al., 1993; Rice et al., 1997; (SEPA), 2003; Wu et al., 2004). Several applications of ozone on landfill leachate treatment have been conducted (Tizaoui et al., 2007), obtaining 27% and 87% removal for chemical oxygen demand (COD) and color, respectively, during the ozonation of leachate. Hagman et al. (2008) obtained 22% COD reduction. Rivas et al. (2003) conducted 30% depletion of COD. Although ozone is effective in stabilized leachate treatment, its effectiveness will be improved using advance oxidant materials and techniques. By employing hydrogen peroxide in advanced oxidation during the ozonation process, Tizaoui et al. (2007) obtained a COD removal of 27%, whereas Hagman et al. (2008) obtained a COD removal from 22% (ozone alone) to 50%. Goi et al. (2009) obtained a COD removal from 24% to 41% at varying pH from 4.5 to 11, respectively. Ozonation and Fenton are now being used increasingly in landfill leachate treatment. These processes are generally applied as pre-treatment (Gau and Chang, 1996; Geenens et al., 2000; Haapea et al., 2002; Kamenev et al., 2002; Fang et al., 2005; Goi et al., 2009 Cortez et al, 2010) or post-treatment (Iaconi et al., 2006; Vilar et al., 2006; Goi et al., 2009) stages in the consequence of improving the efficiency of the treatment. In the present study, a new treatment process ($O^3/H_2O_2/Fe^{2+}$) was introduced by employing the Fenton reagent in the advanced oxidation process for the treatment of stabilized solid waste leachate by ozone as one treatment stage. The main objective of the present study is to investigate the performance of employing Ozone/Fenton reagent in advanced oxidation in treating different concentrations of semi-aerobic stabilized leachate.

2. Materials and methods

2.1 Leachate sampling and characteristics

Leachate samples were collected from a leachate aeration pond of a semi-aerobic stabilized landfill leachate at Pulau Burung Landfill Site (PBLS), Byram Forest Reserve in Penang, Malaysia. PBLS has an area of 62.4 ha, of which 33 ha are currently operational and receive about 2200 t of municipal solid waste daily. It is equipped with a natural marine clay liner and three leachate collection ponds (Bashir et al., 2011). On March 14 and June 17, 2011, approximately 20 L of leachate was collected manually and placed in plastic containers. The samples were transported immediately to the laboratory, characterized, and cooled at 4 ^{o}C to minimize the biological and chemical reactions. The average characteristics of the leachate used in the experiments are summarized in Table 1. Sample collection and preservation were done in accordance with the Standard Methods for the Examination of Water and Wastewater (APHA, 2005).

Table 1: Characteristics of quality of semi-aerobic landfill leachate from PBLS

Parameters	Value*
COD (mg/L)	2180
BOD (mg/L)	70
BOD_5/COD	0.032
NH_3-N (mg/L)	1065
Color (PT Co.)	4100
pH	8.5
Suspended solids (mg/L)	197
Conductivity, (µS/cm)	17,880

*Average of two samples taken from March and June 2011.

2.2 Experimental procedures

All experiments were carried out in a 2 L sample using an ozone reactor with height of 65 cm and inner diameter of 16.5 cm, supported by a cross column ozone chamber for enhancing ozone gas diffusion (Figure 1). Ozone was produced by a BMT 803 generator (BMT Messtechnik, Germany) fed with pure dry oxygen with the recommended gas flow rate of 200 ml/min ±10%. Input ozone concentration was 80 g/m^3 NTP ± 0.5% under 1 bar pressure. Gas ozone concentration (in g/m^3 NTP) was measured by an ultraviolet gas ozone analyzer (BMT 964). The water bath and cooling system <15 °C supported the ozone reactor. Fenton reagent (H_2O_2/Fe^{2+}) was employed in advanced oxidation during the ozonation of stabilized leachate. Hydrogen peroxide (H_2O_2, 30%) and ferrous sulfate heptahydrate ($Fe_2SO_4.7H_2O$, 278.02 g/mol)

were used in preparing the Fenton reagent, and then added to the leachate sample into the ozone reactor. The optimal dosage of Fenton reagent (0.05 mol L^{-1} (1,700 mg/L) H_2O_2 and 0.05 mol L^{-1} (2,800 mg/L) Fe^{2+}) at pH 7 was obtained through a set of preliminary experiments. Different concentrations of leachate were used during the ozonation experiments. The initial COD varied between 250 and 2360 mg/L, the color varied between 470 Pt. Co. to 4530 Pt. Co., and NH_3-N varied between 150 mg/L to 1170 mg/L. The leachate concentrations were adjusted using the following formula:

$$C_1V_1 = C_2V_2 \quad (1)$$

where C_1 is the original concentration of COD before it was watered down or diluted, C_2 denotes the final COD concentration after dilution, V_1 is the volume to be diluted, and V_2 represents the final sample volume after dilution.

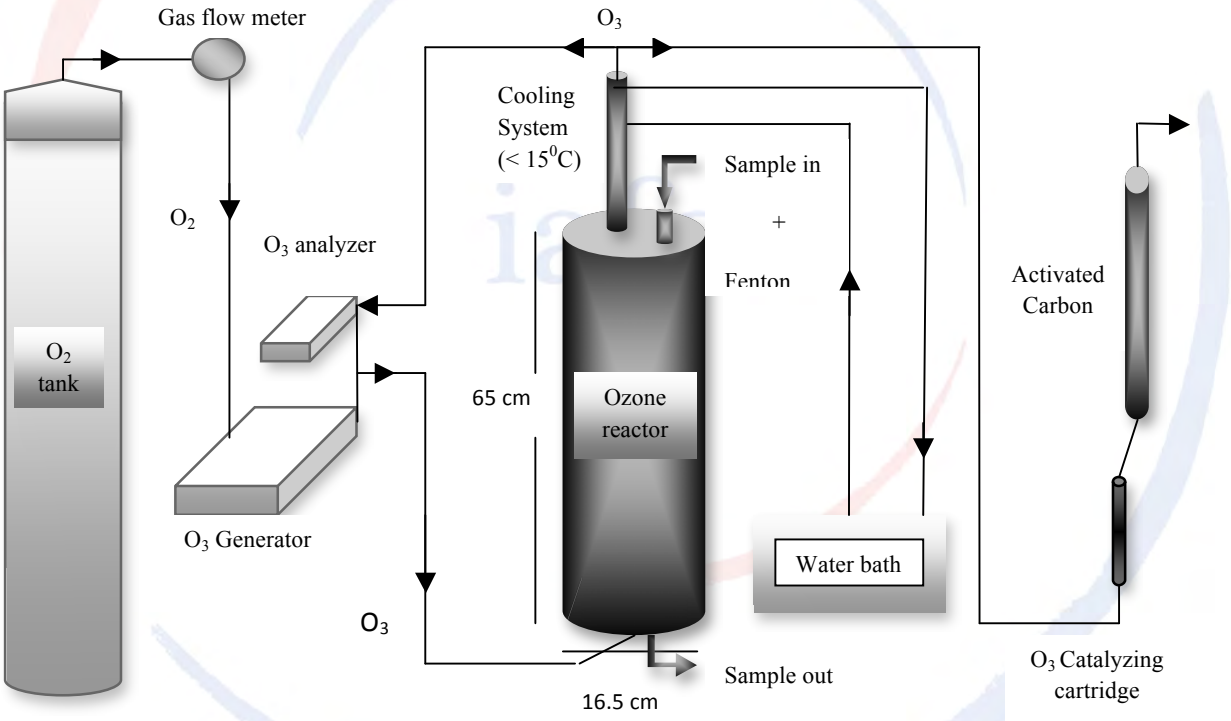

Fig. 1: Schematic diagram of ozone equipment and experiments procedures

2.3 Analytical Methods

COD, color, NH_3-N, and pH were tested immediately before and after each run of the experiments in accordance with the Standard Methods for the Examination of Water and Wastewater (APHA, 2005). The concentration of NH_3-N was measured by the Nessler Method using HACH DR 2500 spectrophotometer, whereas pH was measured by a portable digital

pH/Mv meter. COD concentration was determined by the closed reflux colorimetric method using DR2500 HACH spectrophotometer. Color concentration was measured using DR 2600 HACH spectrophotometer. BOD_5 was measured according to Standard Methods (APHA, 2005). The removal efficiency of COD, color, and ammonia were obtained using the following equation:

$$\text{Removal (\%)} = [(C_i - C_f)/ C_i] * 100 \quad (2)$$

where $C_i - C_f$ are the initial and final COD, color and ammonia concentrations, respectively.

3. Results and Discussion

3.1 Treatment efficiency

To investigate the efficiency of employing ozone/Fenton in the advanced oxidation process for different concentrations of stabilized leachate treatment, a set of experiments with different initial COD concentrations were achieved in the ozone reactor by adding optimal Fenton dosage (0.05 mol L^{-1} (1,700 mg/L) H_2O_2 and 0.05 mol L^{-1} (2,800 mg/L) Fe^{2+}) at pH 7. Fenton is used for improving the oxidation potential during ozonation. The initial COD varies between 250 and 2360 mg/L. Figure 2 illustrates the removal efficiency of COD at different initial COD of stabilized leachate. The removal efficiency ranged from 60% to 87%, whereas the maximum removal corresponded with the lowest initial COD concentration (250 mg/L). For color removal, the treatment efficiency was much better, which ranged between 95% to 100% (Figure 3). As shown in Figure 3, the total removal of color was obtained at less than 750 mg/L initial COD. However, the removal efficiencies of COD and color were more efficient at initial COD less than 1500 mg/L. The reaction of ozone with hydrogen peroxide gives rise to •OH radicals. H_2O_2 is also dissolved in water and dissociates into a hydro peroxide ion (HO_2^-), which reacts rapidly with ozone to initiate a radical chain mechanism that leads to hydroxyl radicals (Staehelin et al., 1982; Glaze et al., 1987) Tizaoui et al. (2007) obtained 50% and 87% removal efficiency of COD and color, respectively, using H_2O_2 as advanced oxidation during the ozonation of stabilized leachate. Nevertheless, the removal efficincy of ammonia by system $O_3/H_2O_2/ Fe^{2+}$ is relatively low, which ranged from 12% to 22% at different initial concentrations of ammonia (150 mg/L to 1170 mg/L) (Figure 4). The removal of ammonia is attributed to the contribution of sulfate at high pH (8 to 9) during the reaction process, as ferrous sulfate (Fe_2SO_4) is a part of the Fenton reagent. Deng and Ezyske (2011) obtained 100% ammonia removal by sulfate radical as advanced oxidation of mature leachate at pH 8.3.

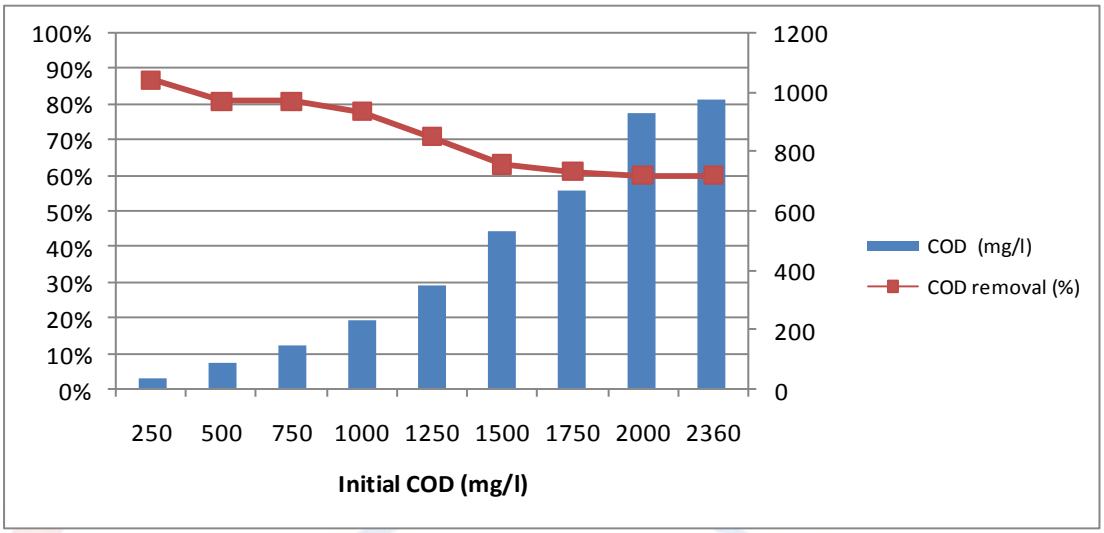

Figure 2: Effects of Initial COD concentration on removal of COD by Ozone/Fenton in the advanced oxidation process (O_3= 80, H_2O_2 = 1700 mg/L, Fe^{2+}= 2800 mg/L, pH= 8.3, RT= 60 min)

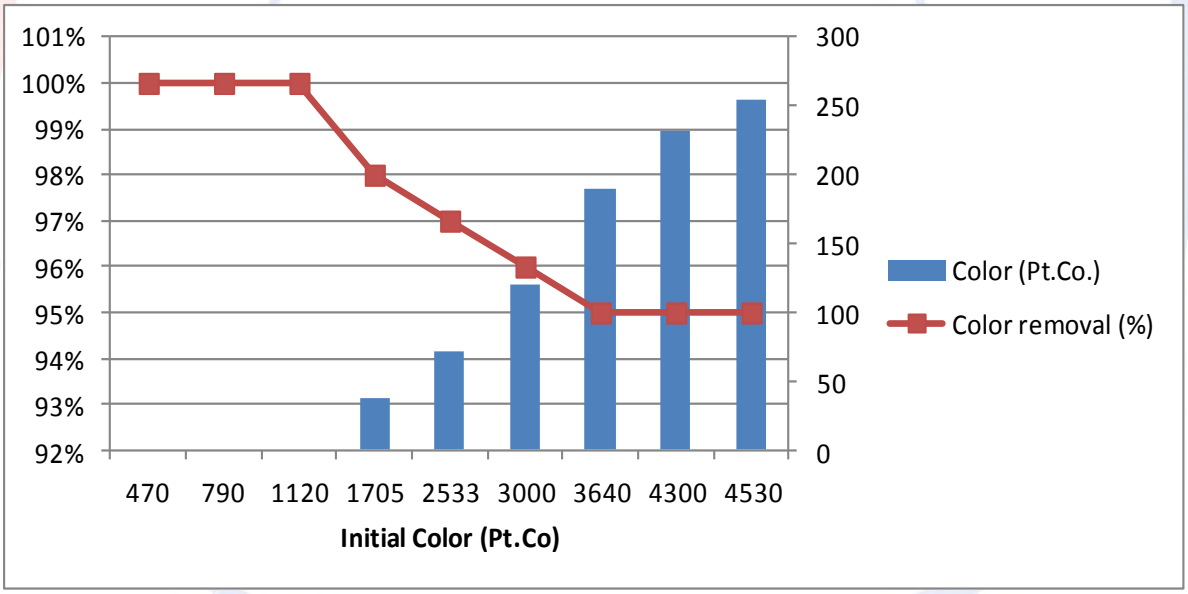

Figure 3: Effects of Initial Color concentration on removal of Color by Ozone/Fenton in the advanced oxidation process (O_3= 80, H_2O_2 = 1700 mg/L, Fe^{2+}= 2800 mg/L, pH= 8.3, RT= 60 min).

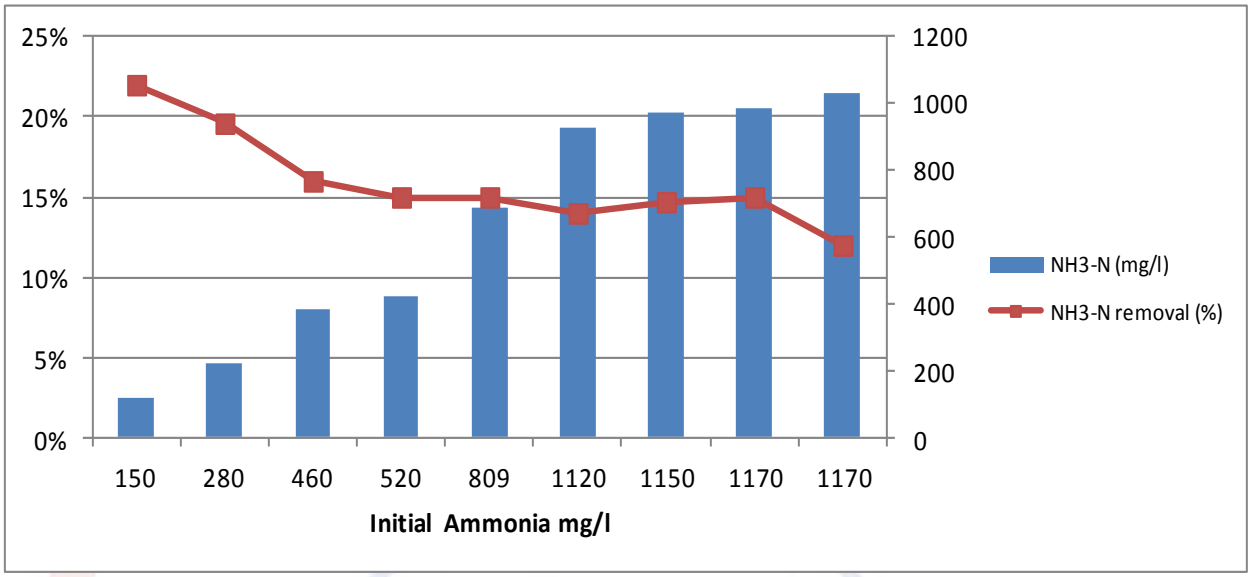

Figure 4: Effects of Initial NH_3-N concentration on removal of NH_3-N by Ozone/Fenton in the advanced oxidation process (O_3= 80, H_2O_2 = 1700 mg/L, Fe^{2+}= 2800 mg/L, pH= 8.3, RT= 60 min)

3.2 Biodegradability

One of the major environmental problems for solid waste landfill-stabilized leachate is low in biodegradability. The performance of a system ($O_3/H_2O_2/Fe^{2+}$) in the advanced oxidation process (APOs) on biodegradability of stabilized leachate was evaluated. COD is a measure of oxidizable organic matter, whereas BOD_5 is a measure of biodegradable organic matter. The BOD_5/COD ratio is considered as a measure of biodegradability of organic matter and shows the maturity of landfill leachate, which typically decreases over time (Tchobanoglous et al., 1993; Qasim and Chiang, 1994). BOD_5 measurements were performed before and after each ozonation process to assess the effect of initial COD concentration on biodegradability of stabilized leachate, and the results are presented in Figure 5. As shown in Figure 4, the BOD_5/COD ratio varied from 0.09 to 0.27. Generally, the ratio becomes higher by reducing the initial COD, especially when it is lower than 1500 mg/L. However, the highest ratio corresponds to 500 mg/L initial concentration of COD. The results in the current study proved that the system ($O_3/H_2O_2/Fe^{2+}$) in AOPs becomes more efficient in improving biodegradability in lower concentrations of semi-aerobic stabilized leachate. Several studies have exhibited improvement of biodegradability following treatment of leachate by ozone based on the AOPs. Tezaoui et al. (2007) obtained 0.7 improvement using O_3/H_2O_2. Bila et al. (2005) reported 0.3 improvement by conjunction ozone with physiochemical treatment and biological process.

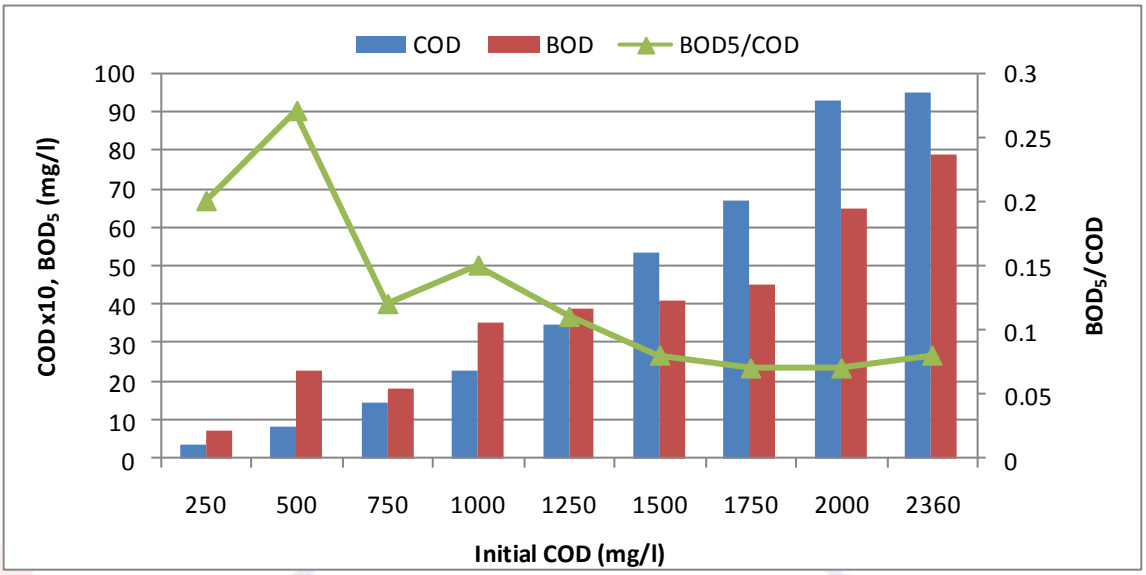

Figure 5: Effects of Initial COD on BOD_5/COD ratio in treatment of leachate by Ozone/Fenton in the advanced oxidation process

3.3 Ozone consumption

Ozone consumption (OC) during oxidation process was calculated using Equation (3). The result is given in Figure 6.

$$OC = \frac{Q_G}{V} \times \frac{\int_0^t \left(1 - \frac{C_{AG}}{C_{AG0}}\right) dt}{\left(COD_0 - COD\right)} \quad (3)$$

where QG is gas flow rate, V is sample volume, C_{AG} is off-gas ozone concentration, C_{AG0} is input ozone concentration, t is time, and COD_0 and COD correspond to the initial and final COD, respectively (Tezoui et al., 2007).

Figure 6 illustrates the OC after 60 min ozonation for different initial concentrations of stabilized leachate compared with COD removal efficiency. As shown in Table 2, the lowest OC value (1.28 KgO_3/Kg COD) corresponds to 60% removal efficiency of COD. Previous studies have reported OC values. Tizaue et al. (2007) and Wang et al. (2003) reported 1.5 and

16 kgO_3/kg COD using hydrogen peroxide as advanced oxidation, whereas approximately less than 1 kgO_3/kg COD was reported by Ho et al. in 1974.

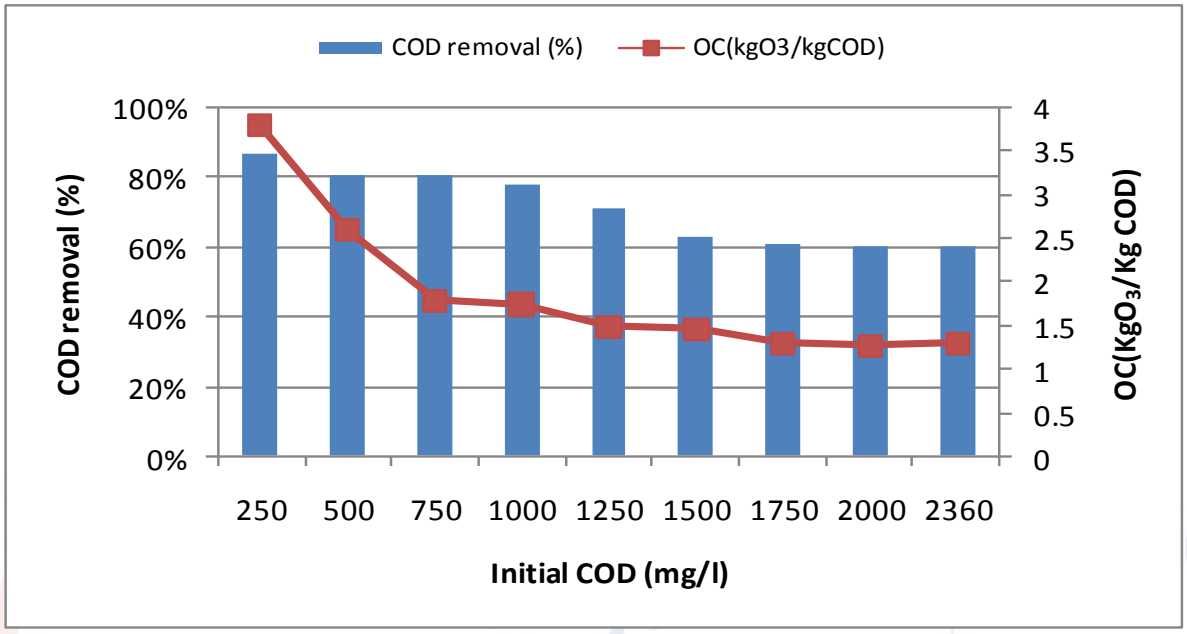

Figure 6: Ozone consumption during ozonation of different leachate concentration by Ozone/Fenton in the advanced oxidation process

4. Conclusion

In the present study, the performance of system ($O_3/H_2O_2/Fe^{2+}$) in the advanced oxidation for removing COD, color, and ammonia from different concentrations of semi-aerobic stabilized leachate was investigated. The initial COD varied between 250 and 2360 mg/L, color varied between 470 Pt. Co. to 4530 Pt. Co., and NH_3-N varied between 150 mg/L to 1170 mg/L. Accordingly, the removal efficiencies varied between 60% and 87% for COD, 95% to 100% for color, and 12% to 22% for NH_3–N. Ozone consumption for COD removal was calculated, and the lowest amount of consumed ozone (1.3 KgO_3/ Kg COD) corresponded to the highest initial concentration of COD (2360 mg/L), with 60% removal of COD during 1 h ozonation. Moreover, the biodegradability (BOD_5/COD) ratio improved from 0.09 in raw leachate to 0.27 at 500 mg/L initial COD. Ozone/Fenton is an efficient method for stabilized leachate treatment and for improving biodegradability at natural pH, which suggests enhancement of the availability of applying biological treatment of leachate without pH adjustment of the effluent after ozonation.

Acknowledgements

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Sustainable Housing Strategies for the Growing Indian Demographics: Contextual Study of Mysore, India

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Abstract:

For developing nations the development of sustainable communities has to go hand in hand with the achievement of wider goals, where emphasis has to be given to the importance of lifestyle and social change. This inter-disciplinary research draws understanding from the social, cultural and economic studies to define the values and aspirations of the middle class and its implications on sustainable housing. One of the fastest growing economies in Asia, India, has empowered a large and powerful consumer oriented middle class. Middle class mores are aspirational and aimed at achieving western living standard and moving away from a traditional communitarian social model. This research presents the results of extensive field work in the southern-Indian city of Mysore that defines the values held by the emergent middle-class in respect to the built environment. Common areas and shared spaces have traditionally been very actively used and have played a crucial role in both passive cooling strategies and the maintenance of socially sustainable communities. Field work shows that attitudes to the built environment are polarised between well-maintained and protected housing interiors and poorly organised and maintained external spaces and examines how these transition spaces are used to reflect these values and concerns. The paper reflects on whether earlier traditions in sustainable building design in South Asia (Mysore) have relevance in a contemporary context and the importance of understanding the changing preferences and values of the newly affluent demographic.

Introduction:

Those nations in the developing south inevitably differ in their approaches to sustainable development (Skea, 2008). The imperative to reduce poverty and increase economic activity means that resource use will grow to meet the legitimate aspirations of both government and society and this has to be reconciled with transnational concerns to promote sustainable strategies for the future. As Gay has argued, economic expansion is required before the recognised process of contraction and convergence takes place in concert with the developed world. (Mayer, 2004). Our research engages with sustainable development in its widest sense as formulated through the Bruntland (Brundtland, 1987) definition of interdependence between social, economic and environmental realms.

Our research is based on whether such assumptions still hold true for the design of housing that might appeal to the burgeoning Indian middle class. This has been achieved through two intensive periods of fieldwork to uncover the key drivers to housing development in the middle income demographic. This has been done through mapping activity, structured interviews and questionnaires with key stakeholders. These include architects, builders, developers, planners, householders and potential purchasers. The work was undertaken in Mysore, India (Figure 1). The first published stage of the research clearly reflects a shift away from climate responsive, socially inclusive, community oriented housing to a more individual, exclusive and independent housing typology (Satish et al., 2011). This paper is concerned with the second stage of the fieldwork that market tests with key stakeholders, potential sustainable design strategies that also meet the expectations of the middle income consumer. We describe the methodology for construction of a series of scenario models for market testing as well as using simulation techniques to benchmark the models to a series of quantitative indicators.

The fast growing Indian economy has empowered an emergent middle-class whose new-found economic status and affluence have a critical impact in the process of sustainable development (Fernandes, 2000b, Fernandes, 2000a, Singh, 2009, Wessel, 2004). A former class identity based on simplicity has been transformed by the economic empowerment to one of affordable indulgence (Varma, 1999). Consumerism has become the primary Indian value, fuelled by the influence of the west and a more pervasive media (Fernandes, 2006).

In an Indian context, changes in housing procurement and design are as much a social and cultural phenomenon as a technical one. A recognition of this fact can allow insights into the effective formulation of localised, resilient and relevant sustainable housing strategies that address quantitative issues such as carbon reduction (Skea, 2008). India's economic growth has also increased the spending power of the middle-class (Fernandes, 2006). Changing lifestyles and consumption patterns have clear impacts on housing (Swarup, 2007, Imtiaz and Helmut, 2001). Although increased affluence and consumption benefit the middle-class, it has also increases carbon emissions (Saavala, 2003). 60% of the emissions originating from construction activities are attributed to the housing sector (Tiwari, 2003).

This increase in energy consumption is not limited to ownership of more consumer goods but can also be attributed to changes in housing typologies resulting from changing expectations of home owners. (Satish and Brennan, 2010). Traditional middle income housing as studied by the authors was communally configured with a looser relationship between external and internal realms. Contemporary dwelling templates now reflect a culture of individuality that feature highly defined boundaries forcing dwelling activities into air conditioned interiors with resource and carbon implications (Satish et al., 2011).

Figure 1. India map: Mysore location

In the case of Mysore (Figure 1), a south Indian city, traditional residential layouts were either linear with a shared party wall, or with houses distributed around an open space (Figure 2). Entry to the house was through a semi open raised platform (Jagali) (Issar, 1991). These Jagalis were shaded for most of the day and used extensively for socializing and actively used as interaction areas (Ikegame, 2007). Jagalis worked as an effective climate mediating transition space and there were no other boundaries to define individual territories. Materials used for construction, thick mud walls (later brick) and terracotta tile roofs were locally sourced and with small openings towards shaded areas, they were climate responsive and exhibited sustainable features in their material choice and construction details.

Shared facilities and the efficient use of semi-open outdoor spaces for much of the day also resulted in a compact building footprint. Such climatically responsive layouts and construction using locally available material are good example of efficient sustainable development (Vandana, 2008). These houses were thermally comfortable due to planning techniques which reduced solar gain and due to the use of local materials and construction details which were climate responsive and had low ecological footprints (Satish et al., 2011).

Housing design and residential layout both changed drastically after independence in 1947. It can be argued that a move from communal provision predates contemporary economic expansion and its attendant societal changes, a sense of the communal being replaced by a priority to preserve privacy. Contemporary housing designs feature large openings, a defined and fenced plot boundary (Figure 3) making each building self-contained and introspective (MUDA, 2005). Roads, independent of houses, have pedestrian ways and are clearly segregated from the property of private individuals by fencing into compounds. This is supported by local planning legislation (MUDA, 1996). It is an embedded expectation that buildings no longer enclose and define the open spaces and encourage outdoor activities (Satish et al., 2011, CITB, 1987).

Figure 2. A typical Agrahara, Jagali typology

Figure 3. New houses

Altered social and cultural values have played a crucial critical role in the adoption of new housing typologies. Changed social conditions mean that people have started to associate the strengths of community living with weaknesses. For instance, shared facilities are interpreted as leading to a lack of privacy (Satish et al., 2011).

A new housing typology has been inadvertently implemented that does not reflect local climatic conditions and this has led to increased consumption of operational energy (Figure 3). As an executive engineer responsible for urban housing development recollects, until 1970 people were careful to stay close to the city centre (Fort and Palace) (respondent no.12, interviewed on 23 July 2009). To encourage residents to move away from city centre, the City Improvement Trust Board (CITB) built houses in plots and allotted some sites free of cost for those who bought houses away from the city centre (CITB, 1987). This has had a direct impact on the land footprint (figure 4). Whereas in the earlier Jagali typology, nearly thirteen square meter of land is used per person this has increased to 27 square meters per person (CITB, 1987). Now, middle class people prefer the plot typology and the land footprint have increased up to 43 square meters per person (MUDA, 1996, MUDA, 2005). Emphasis on privacy has resulted in use of further resources to protect property. Improved financial resources coupled with changing aspirations have contributed to building bigger houses and the choice of imported materials to reflect their owners' aspirations. These have clearly increased the embodied energy of houses (figure 4). Changing social and cultural needs have resulted in climate responsive spaces like Jagalis becoming redundant. Social activities have moved indoors coupled with large windows, increasing conductive heat gain and increased comfort expectations have resulted in use of more lighting and spot cooling, all of which has increased operational energy requirements (figure 4).

Unsustainable development can be identified at every level. The first published stage of the research clearly reflected and summed up the unsustainable features of community living, siting, entrances, house planning, finishes and facades. Reflecting on the earlier work, the second stage of the research focuses on a particular sections of the house to investigate the specific rationale for the changes, people's preferences and their implications for sustainable housing.

Housing is thereby identified as a social and cultural phenomena and this research looks at built environment sustainability from a more bottom-up perspective. Earlier research clearly indicated changes at all levels but more so at the entrance point, the transition from street to main door. This area clearly demonstrates people's preferences, aspirations and changed attitudes and their impact on housing form. It is also impacted on by reconfigured layouts, preferences and requirements of home owners.

The research focuses on this boundary condition and the second stage of the field work engages with key stakeholders in examining sustainable design strategies that could also meet the expectations of the middle income consumer.

Boundary condition and its implication on sustainable housing:

It has been argued that the pre-industrial architecture of India served the physical and spiritual needs of the populace well. At a physical level, it demonstrated an understanding of the local climate, available materials and construction techniques. Doshi has argued that "at the spiritual level, the built-form conveyed total harmony with the regional lifestyle in all its daily as well as seasonal rituals, unifying the socio-cultural and religious aspirations of the individual and the community" (Ameen, 1997).

Closer inspection reveals that the key change has been the way the house boundary is defined and the values and changes taking place at this interface. As Correa(1991) has argued, the climatic conditions of most Indian cities allows for the use of open and semi open spaces for interaction, gatherings and other social activities (Correa, 1991). Correa identified specific Indian conditions, which aid sustainability. They use natural light for most part of the day and very minimally construction, which reduces embodied energy. He has identified (Correa, 1991) four major elements as:

1. Internal private spaces
2. Area of inmate contact (the front door step)
3. Neighbourhood meeting places
4. Principal urban area

In a traditional Indian context, these spaces will always have very high usability coefficients due to the nature and way these spaces are used (Correa, 1983). Though the notion of threshold is a theoretical construct used in sociology, anthropology, and architecture, primarily in a western context. It is none the less relevant in interrogating modern urban conditions in India.

The research is thus focussed to these boundary conditions as they may reflect fundamental changes since Correa's writing about threshold. Although relevant in 1990, such has been the change in society that a virtuous link between building form, bioclimatic response and social structures in the household may be broken. We therefore examine whether contemporary expectations regarding security and privacy have anything to offer sustainable design strategies and if any of the more traditional approaches to threshold and form can be incorporated in the design of new housing.

Models and simulation analysis:

We aim to use the observations and conclusions of the earlier research and field work to identify the needs and wants of middle class home owners. Structured interviews and surveys clearly indicated the concerns for security and notions of protecting one's boundary, coupled with the need for privacy, and the use of form and façade to provide visual cues in expressing wealth and aspiration (Satish et al., 2011, Glendinning, 2011).

The understanding of the field work is triangulated with literature studies and the outcomes related to boundary conditions are used to produce different computer models, representing alternatives for major elements, a sustainability agenda and middle class aspirations. Feedback

from architect, builder, and home owner is used to define these models that are then related to sustainable values.

The field work was combined with intensive literature reviews of both contemporary Indian building typologies (MUDA, 2008, Shirley, 2008, Annapurna, 1999, Tiwari, 2001) and research on boundary, threshold and border that help explain contemporary preoccupations with security and defensible space (Blaisse, 2009, Georges, 2005, Georges, 2008, Rashid, 1998, Suzanne and Lennard, 1977). From this a series of four test models were generated for study in respect to both predictive quantitative performance and as a basis for revisiting the fieldwork. The models were organised to test housing market stakeholders' responses to a range of sustainable criteria. At one extent a traditional bioclimatic solution that reflects past models of communal living and at the other extent, a model representative of current private sector middle class housing were constructed. A further two models between these extremes were designed primarily to get a finer understanding of the exact levels of privacy and social interaction that might be embraced by potential stakeholders (Figure 4).

		Model 1	Model 2	Model 3	Model 4
Typologies		Jagali Typology	Jagali + Plot	Plot + Gate	Plot + High Gate
					
Description	Boundary condition	a traditional bioclimatic solution that reflects past models of communal living	A representative model of combination of traditional and current middle class housing. Demarcation of boundary with very low wall. Combination of Jagali and plot system.	a representative model of current private sector middle class housing	a representative model of aspirations and high end / upper middle class housing
	Physical	Sharing party wall either in a row or arranged around the open space.	The plot is defined more as a very low hedge to retain the permeability of the Jagali typology	About four feet high compound Clear definition of one's territory.	Very high compound. Min 6 feet high. Totally cut off from the external world.
	Spatial:	Use of semi open space for most part of the time.	Opportunity to use open space for informal activity	Clear demarcation of territory. Presently, the space is not used for much of the activities.	Well defined barrier segregating the inside and outside. Open space and landscape areas for personal consumption.
	Visual	Visually connected with each other house and central open space. Kids can play around and people can use the Jagali for informal gathering / activity.	Developed more to suit the prevailing plot typology. Scope for interaction among neighbours.	There is a visual connection if not physical. Owners have the option to interact with the neighbours.	Insulated and visually cut off from the street and neighbours.
Qualitative	Communal / Social	Community oriented. Common open space and other than the rear utility area, there is no individual house open space.	Scope to use open space for most part of the day.	Scope for informal interaction with the neighbours and street. Not much importance for the exterior open spaces and community activities.	Totally cut off from the neighbours. Introvert, independent and more importance for privacy. Independent of neighbours and not involved in community activities.
	Economics / reflection	More emphasis for culture than Economics (Rangoli). More functional	More functional	Combination of function and appears. Skin and compound used for demonstration of one's aspiration.	Skin and compound used for demonstration of one's aspiration.
	Security	Social Security, compact community and new members are identified by people.	More importance for social security	Compound used as a psychological barrier, main door with steel shutter	Compound itself acts as first level of defence. Totally grill and very high individual security.
Quantitative	land foot print	13 Smt / person	27 Smt / Person	27 Smt / Person	43 Smt / Person
	Embodied energy	Use of Least embodied energy and lifecycle energy.	Less embodied energy	Relatively high lifecycle energy.	Use of very high embodied energy and lifecycle energy.
	Embodied energy	0.47 MWh / SQM	0.57 MWh / SQM	0.63 MWh / SQM	0.78 MWh / SQM
	carbon emission	0.24 t CO2 / SQM	0.29 t CO2 / SQM	0.33 t CO2 / SQM	0.40 t CO2 / SQM
	Openings	Very small, just enough light inside.	Narrow openings, Enough light for the interiors.	Wide openings, no relation to direction and requirements.	Very wide openings. Spanning most part of the wall.
	Climate responsive features	Climate responsive, roof, wall, construction and materials were reflective of local climate	Jagali area is shaded and could be used for most part of the day.	Design is independent of climate	Highly insensitive to the climatic condition.
	source of material	Use of locally sourced materials.	Emphasis on use of locally sourced materials	Combination of local and imported materials.	Use of imported materials.
	Security	No/ Least materials used for security other than the regular wooden door.	Steel door as additional security to the main and rear door.	steel grill for the portico area	entire plot or most part is covered by grill.
Summary		Most sustainable typology	Some of the features are sustainable	Some of the features are unsustainable	Least sustainable typology

Figure 4. Analysis of different model typologies

	Typologies	Model 1 Jagali Typology	Model 2 Jagali + Plot	Model 3 Plot + Gate	Model 4 Plot + High Gate
	General description				
Volume	Different activities and their features are highlighted. Each typologies represent most desired to most prevailing and also vernacular typology.	There is no demarcation of private spaces and public areas. Sharing party wall either in a row or arranged around the open space.	The plot is defined more as a very low hedge to retain the permeability of the Jagali typology. A representative model of combination of traditional and current middle class housing.	This most prevailing model has physical barrier between street and inside plot. The height of the wall is about four feet, where the homeowners can still retain some connection with street and neighbours. Portico defines the main entrance and also acts as informal reception area of guests.	this most aspiring model has clear definition of internal and external part of individuals space. High wall, gate and elaborate portico emphasis the status of the person.
Entrance	Main relation of street and Entrance door, different activities between the two are explored.	There is a smooth transition from street to main door through semi open raised area (Jagali). Jagali is used for most part of the day.	Similar to Jagali typology entrance with additional space in the front with hedge to define ones plot area.	Direction of the opening is influenced by many factors and owners tend to locate the main door close to street and additional open space near the main door used for parking two wheel and four wheel vehicles.	Main door is recessed inside the individual property and not visible from the street. There is no relation between street and main door.
Opening	Larger openings will increase conduction gain and increase cooling load. Different alternatives are worked out based on the window size and two more models are developed to examine peoples preference of overlooking shared spaces.	Very small, just enough light inside.	Narrow openings, Enough light for the interiors.	Wide openings, no relation to direction and requirements.	Very wide openings. Spanning most part of the wall.
Security	Concern of safety and both perceived and real threat are reflected the way the boundary and openings are protected. Different level of security are represented in each model.	Social Security; compact community and new members are identified by people. Least materials used for security other than the regular wooden door.	Emphasis on social security. Steel door as additional security to the main and rear door.	Compound used as a psychological barrier and main door with steel shutter. Most of the cases steel grill for the portico area.	Compound itself acts as first level of defence. Very high individual security. entire plot or most part is covered by steel grill.
Interaction	Interaction among neighbours and home owners is the crucial part of the boundary condition. Different typologies represent degree of interaction among community.	Community oriented. Common open space. Visually connected with each other. Kids can play around and people can use the Jagali for various activity.	Scope to use open space for most part of the day. Developed more to suit the prevailing plot typology. Scope for interaction among neighbours.	Scope for interaction with the neighbours and street. There is a clear physical barrier and visual connection. Owners have the option to interact with the neighbours.	Both physically and visually cut off from the neighbours. Importance for privacy. No interaction with neighbours and not involved in community activities.
Skin	Skin used for elevation, is either construction material used as masonry or cladding for the entrance and front side of the building. The choice of material is independent of building typology. However, peoples preference of each typology is listed.	Use of locally sourced materials. Use of Mud blocks	Emphasis on use of locally sourced materials. Use of Brick and mud blocks	Combination of local and imported materials. Mostly Plastered with entrance area and street side clad with stone or Tiles	Use of imported materials. Emphasis on aesthetics and cost of the material. Extreme of use of polished granite and imported materials and also cement tiles.

Figure 5. Description of Elements of different model typologies

The model prepared reflecting the prevailing typology (model 3): has an approximately 4 feet high compound between neighbouring plots. The front and rear of the plot has a minimum set back of 1 meter or as required by the BDA regulations. The aspiring one (model 4): has a very high compound that insulates it from external world and extensive use of imported material and ostentatious finishes and very wide openings. The earlier Agrahara typologies (model 1): is the early typology with a raised platform in the front with small openings and use of locally available material, overlooking the street. Finally based on the feedback from the first field work, a combination of climate responsive and aspirational typology (model 2) was developed (Figure 5).

The models were generated with similar configuration in terms of built up area, number of rooms, size of the plot and provision for minimum light and ventilation. To focus the research more on the boundary conditions, all other components such as constructional systems and spatial planning were kept as constants. Each option was then modelled first in Google Sketch Up then exported into environmental simulation package, Integrated Environmental Systems (IES), to predict energy consumption and carbon emissions. Longitude and latitude were specified for Mysore using hourly climate data from Bangalore, the nearest city to the study area.

Before testing stakeholders' responses to the models for, the models were validated for their predictive quantitative performance by simulating them using environmental design software. An advanced simulation package, Integrated Environmental Solutions (IES), was used in this research. IES uses climatic data and supports a range of analytical tools for lighting, thermal comfort and resultant energy consumption and carbon emission. To predict energy consumption and carbon emissions, longitude and latitude were specified for Mysore using climate data from Bangalore, the nearest city to the study area.

The results of the simulation for each of the four models are shown in Figures 6, 7 and 8 in respect of conductive heat gain, cooling load, peak energy demand and carbon emissions for a representative day; May 19, one of the hottest days chosen to analyse the heat gain and energy consumption due to cooling. The focus of this research is to access the implication of varied boundary condition in terms of change in energy consumption and resultant carbon emission. For the simulation purpose, only these boundary conditions of different typologies are altered while providing input in IES. For instance, the internal parameters like number of rooms, number of occupants, comfort condition expected inside the house, minimum light, and ventilation desired is kept constant across all the models. Details like size of the openings and their location are altered among the models. Similarly, the construction materials and internal partitions are kept constant, whereas the external finish either the cladding or plastering or use of construction material as external fabric, are altered as defined in each typology. Finally, the boundary condition as shared party wall, independent plot system, four feet compound and very high compound with high gate details are constructed and fed to IES.

IES allows altering the input of each typology while retaining some of the features as constant across all typologies. Further, it allows comparison of specific parameter across typologies during output. For instance we can run the models to simulate only the conductive heat gain, where the internal temperature rise is due only to heat gain by conduction. Similarly, the energy consumption due to cooling load, resultant of bringing down the internal temperature to set comfort condition is assessed (Figure 6, 7 and 8).

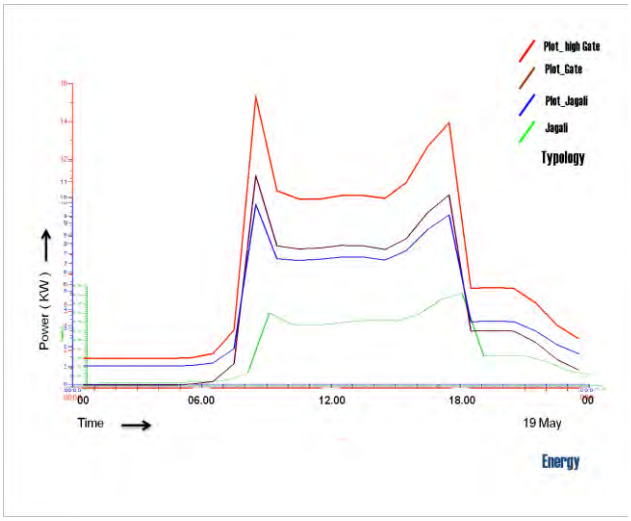

Figure 6. Energy consumption

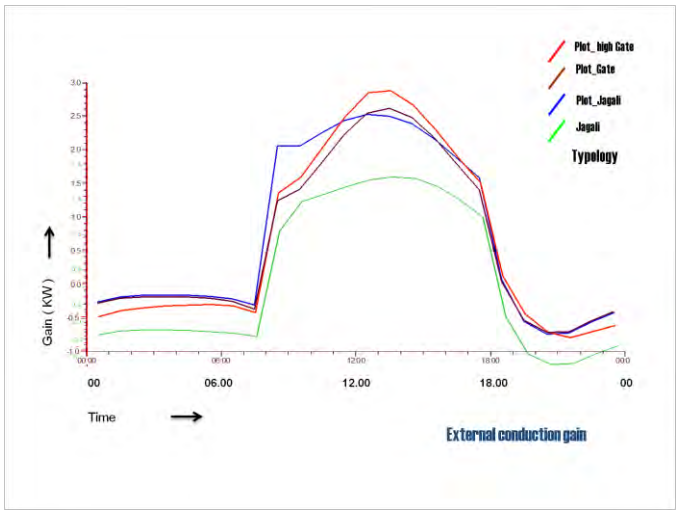

Figure 7. Conduction heat gain

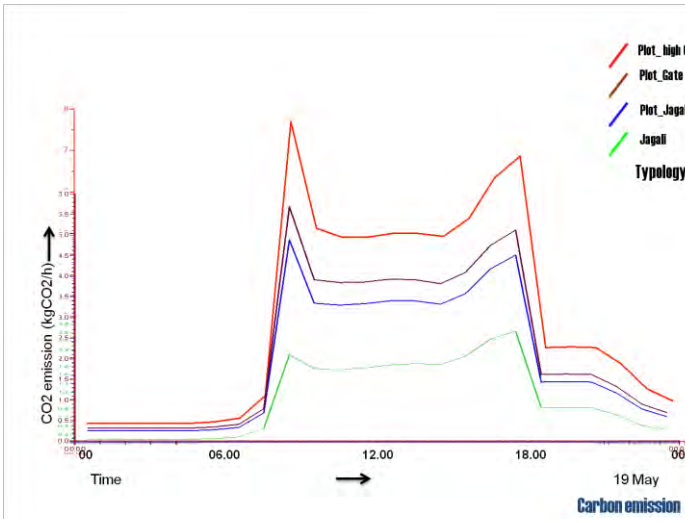

Figure 8. Carbon emission

The outcome clearly indicates higher conduction gain, cooling load, energy consumption and resultant carbon emission in plot and high gate typologies and consistently lowest energy consumption and carbon emission in the Jagali typology.

A key finding is one of increased energy consumption in model 4 representing the aspirational model. It uses nearly 65% more energy than model 1 (the Jagali typology). Similarly, there are differences in the performance of other models; for instance, in the case of energy consumption, the high compound typology (model 4) requires nearly 300% of more cooling load compared to a Jagali house typology (model 1). And even this will increase the conduction gain by nearly 90%. All the results are tabulated and compared in Figure 9.

IES Simulation Result	Typologies ->	Model 1 Jagali Typology	Model 2 Jagali + Plot	Model 3 Plot + Gate	Model 4 Plot + High Gate
Parameters	General description				
Energy Consumption / SMT	Energy consumed by electrical appliance are considered. To bring in uniformity, it is converted to SMT and all the models are compared to the base results of Jagali typology as 0	Bench mark	20 % of Jagali Typology	35 % of Jagali Typology	65 % of Jagali Typology
Cooling load	This simulation result accounts for the energy consumed to cool the internal spaces to comfort temperature of 23 degree.	Bench mark	100 % of Jagali Typology	200 % of Jagali Typology	300 % of Jagali Typology
conduction gain	Window size is altered in each typology and with other construction materials being constant, the simulation result reflect the conduction heat gain due to size of the opening.	Bench mark	58 % of Jagali Typology	65 % of Jagali Typology	90 % of Jagali Typology
Embodied Energy	Source of the material, energy consumed for the processing and transportation are considered to qualify the other simulation results.	Locally resourced material and construction system. Least materials imported from beyond 10 miles.	Most of the materials Locally resourced and few materials imported from beyond 10 miles.	Some of the materials Locally resourced and few materials imported from beyond 100 miles.	least of the materials Locally resourced and most of the materials imported from far distance.
Total energy consumption	it includes energy consumed due to electrical appliance, maintenance and cooling load.	Bench mark	138% of Jagali Typology	175% of Jagali Typology	275 % of Jagali Typology
Carbon emission / SMT	Total carbon emission due to energy consumed due to maintenance and cooling energy. To bring in uniformity, it is converted to SMT and all the models are compared to the base results of Jagali typology as 0	Bench mark	20 % of Jagali Typology	35 % of Jagali Typology	65 % of Jagali Typology
Summary		Most sustainable typology	Some of the features are sustainable	Some of the features are unsustainable	Least sustainable typology

Figure 9. IES simulation output

The simulation output demonstrates that changed boundary conditions have implications for energy consumption and resultant carbon emission. They also validate the hypothesis while developing models that explore different boundary conditions (Figure 4 and 5). It also clearly points to a direct relation between peoples' changed preferences and aspirations and their implications for energy consumption and carbon emission.

Field Work

The main objective of achieving sustainable strategies within the existing middle class paradigm is achieved by contextualising the broad term of sustainability to Mysore condition on one hand and reflecting the acceptability of middle class home owners' preferences and acceptability on the other. The models prepared and simulations carried out reflect the local sustainability agenda and different levels of sustainability with specific reference to boundary condition. Further field work looked the aspirations of the middle class people and their willingness to align towards more sustainable features.

With the series of scenario models complete, a second series of field work was carried out during Feb – April 2011. Here the research is more focused on testing the acceptability and preferences of home owners by drawing on their feedback to these pre-defined models. The models were tested with home owners by semi-structured interview and with key stakeholders in the design and procurement process. To analyse the issues reflected in transition spaces, elements representing middle class aspirations and the sustainability agenda were identified, namely: Volume, Entrance, Opening, Security, Interaction and Skin.

To elicit preferences and log the choices of people, architects and builders, a 'multi sorting task' methodology was followed. As Groat (1982) has argued, it is possible for the participants either to sort representations of buildings they had experienced directly or pictures that functioned as simulations of the real environments. The models are deconstructed to highlight the element of investigation; for instance, while asking people about their priorities about openings / window size and location, views showing different window conditions were derived from the basic models and prepared so that the participants could reflect purely on the concerned issue and not be distracted by other elements in the images.

This technique is very helpful in this type of study as respondents are asked to place the cards from most acceptable to least acceptable. Once noted, they are given a briefing about sustainable issues in housing and how each model and typology reflects different energy and carbon footprints. Stakeholders are asked to place the cards again in the light of their understanding of the sustainable implications of their choices. Their preferences are noted and the implications of any change in the respondents' choices are ascertained.

This multi sorting process was validated through a semi-structured interview. Apart from noting their preferences, the process was recorded and interviewees were informally questioned as to their decisions.

Field work analysis, Discussion

The outcome of this second stage of field work addresses issues including social and cultural values and perception of key stakeholders towards middle income sustainable housing. The study can be broadly addressed at two levels; firstly, it deconstructs how various stakeholders perceive boundary and threshold in housing. The interview and survey assesses the choices and preference of a particular topology based on issues like, security, material, interaction etc. their choice of

most preferred and least preferred are further triangulated with the discussion during the process about the rationale behind their choices and why they think their choice is appropriate.

At second level, the study analyses how the peoples' perception changes with awareness. The house owners are asked first to prioritise their preferences. Later after being given information on issues relating to climate change and sustainable housing, they are asked to again place their preferences. Feedback from stakeholders; architects, builders, contractors and home owners are analysed for each element identified namely; Volume, Entrance, Opening, Security, Interaction and Materials. Though there is a clear departure from the sustainable boundary condition, the outcome clearly reflects varied preferences among different elements identified. To summaries the field work results; two representative outcomes, Volume and Opening, are discussed below.

Volume

In the case of different Volume options, stakeholders strongly feel that the prevailing plot typology is most desirable followed by high gate typology preferred by more than 65% of home owners. The most sustainable, Jagali typology is the least preferred option (Figure 10). According to an architect interviewed, "Privacy, dust, vibrations due to vehicle movement, forces people to build house away from road" (respondent no.111, interviewed on 11 March 2011). One builder felt that privacy is a major concern and people would not prefer to build "their house on the street without privacy" (respondent no.109, interviewed on 10 March 2011). When their attention was drawn to well established Jagali typology, they feel there is clear deficit of trust among neighbours which is crucial for social / community living (respondent no.98, interviewed on 19 March 2011). Their strong preferences are evident while analysing their preferences after providing the information regarding sustainable concerns. Home owners' revised preferences clearly reflect marginal decrease in the high gate typology, which is reflective of many unsustainable features and less than 10 % increase in the preferences for Jagali typology (Figure 10). Similar trend can be observed among other elements like, Entrance, and Security.

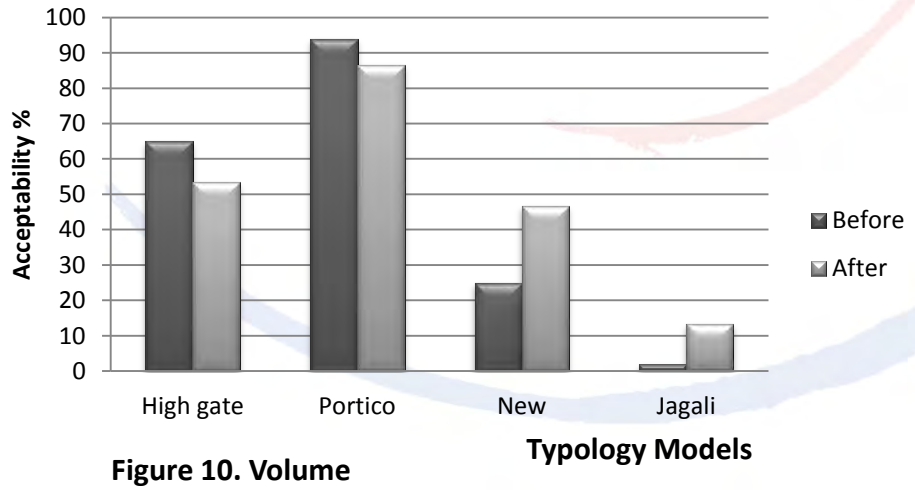

Figure 10. Volume

Opening

In the case of different opening options, stakeholders are divided among the wide, small and inward openings. Less than 10% of home owners prefer opening towards shared areas (Figure 11). According to one architect, changed social network and priorities makes this a least feasible typology (respondent no.76, interviewed on 09 March 2011). One builder posed a more practical

concern of flexible design and spatial organization means these two or four owners will have their own plans and may not match, unless built together and all buy into it (respondent no.115, interviewed on 13 March 2011). The concern and acceptability of the home owners are evident, while their preference for the wide openings are reduced to less than 5 %, their preference for small opening is increased by 20% (Figure 11). Similar trends can be found in case of Material choices as well.

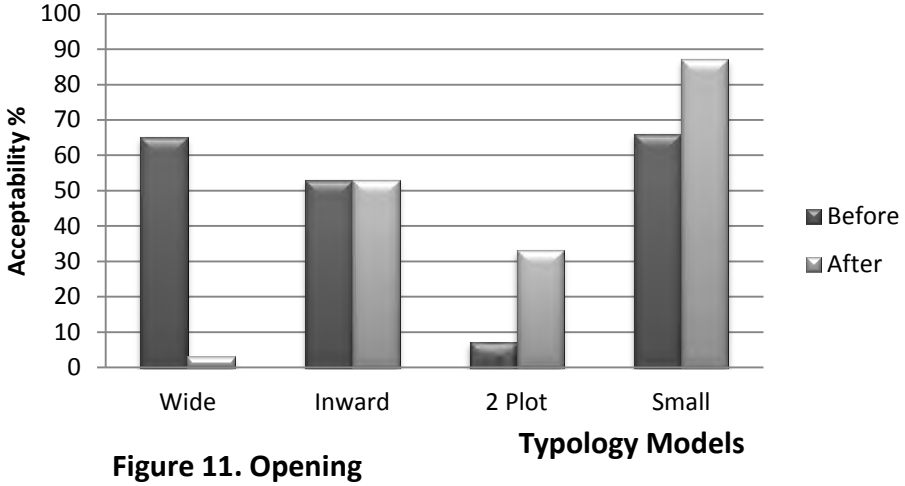

Figure 11. Opening

Analysis of these representative elements reflects the concerns and aspirations of the middle class home owners and also demonstrates variation in their preferences among different elements. The understanding of home owners' perceptions and expectations enables one to produce sustainable strategies which work within an existing middle class paradigm. The outcome of the field work could be summarised based on the level of acceptance of sustainable models and probability of aligning towards Sustainable Housing (Table 1).

Field Work Reflections		
	level of acceptance of sustainable models	probability of aligning towards Sustainable Housing
Volume	Least	Negative
Entrance	Least	Negative
Openings	Most	Positive
Interaction	Moderate	Perhaps
Security	Least	Negative
Skin	Most	Positive

Table 1. Summary of field work outcome

Choices and preferences clearly represent the area in which we can expect people to support and adapt to sustainable features. The feedback can be classified in to three types. First the elements which people are ready to change their preferences for the cause of sustainability, in this we can easily find the materials, skin and openings as two aspects which people are ready to align towards a sustainable agenda. There are certain elements for which they do not have very strong

preferences and to some extent are ready to align themselves. In this case people might consider some adjustment but are not ready to forthrightly support a sustainability agenda.

However when it comes to issues like security; people are not ready to compromise and would not be interested in sustainability issues and would not compromise on their perception of what is safe and secured for them. This study has been very useful in disentangling one area, the boundary condition and look at each element separately so as to identify people's choices and preferences resulting in the housing typology and hence resultant sustainable concerns rather than broadly summing up the boundary conditions as unsustainable in present context.

This study is also helpful in identifying the areas and elements where it is easier to achieve higher sustainable goals compared to areas where there will be higher resistance to change. Revising the model to suit both peoples' choices and sustainable agenda further tests this. Peoples' choices and preferences, collected by social methods, are fed into the IES simulation model to analyse the difference in the process of sustainable housing. To test this one model is altered to have optimum size windows which people would be ready to align with to achieve more sustainable housing.

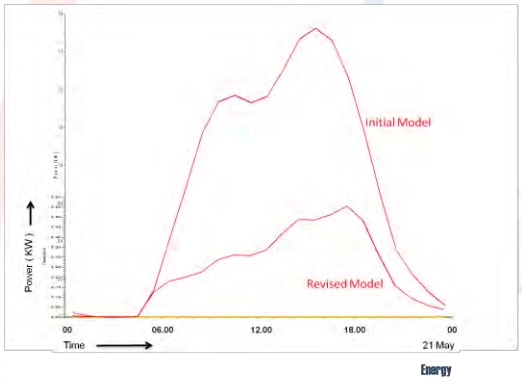

Figure 12. Post-field work: Energy consumption

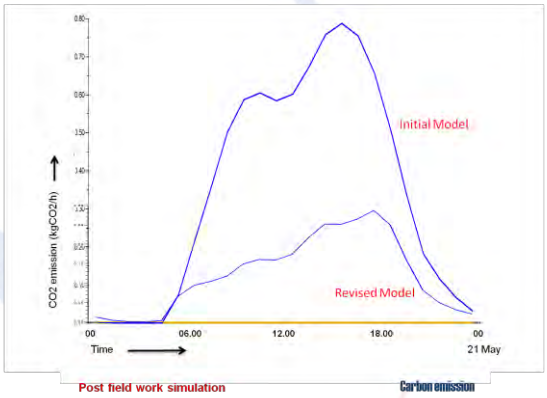

Figure 13. Post-field work: Carbon emission

The new IES simulation chart clearly shows a drop in the energy consumption of 40 % and thus a reduction in carbon emission. The changed window parameter has also reduced the conductive heat gain by 20 %. The results clearly show that, by changing the elements which people are ready to alter, we can reduce carbon emission by a fifth. This is significant because it is useful to know where we can really target and reduce emissions.

Conclusion

The study using survey field work and model simulations has highlighted the relatively recent shift in attitudes and cultural values relating to housing; from an inherently sustainable approach which valued shared spaces, local materials and communal activities, to one which reflects a move towards a twentieth century western approach; of individualism, nuclear families and consumer driven values. The study also clearly demonstrates that there are elements like materials and openings, which people are willing to align themselves with and that there are elements like security, which they would not compromise. Their immediate concerns would be of greater importance than the greater issues of carbon emission and sustainable housing.

The particular points are as follows:

This study has explored the people's attitudes and their implication for housing in India, particularly the people of Mysore. There are however specific factors which are unique to Mysore. For instance, for although aspiration to own a house is an Indian phenomena, middle class home owners in Mysore are particularly desirous of owning a plot and identifying their own territory.

Though there is a clear move away from sustainable living, the values of people can be recognised as being more than 40% ready to change their life style to align themselves towards more sustainable housing.

In the process of achieving more sustainable housing there are factors like security where the perception of the owners plays a crucial role. Though home owners are sympathetic to sustainable concerns, their fear and psychological concerns with regard to security and other issues like unorganised exterior spaces, stray animals and perceived lack of moral values in society has prompted the middle class home owners to define, identify their territory, and protect and insulate their boundaries.

Finally the revised IES simulations demonstrates that nearly 40% energy savings and carbon reduction could be achieved without altering peoples' preferences. Further reduction requires intervention at higher level; for instance to change the entrance and setbacks now prevalent. To achieve this regulations and legislation will have to be reworked. On the other hand concerns about security can only be addressed at regional and policy levels.

We have to acknowledge the need for people to express and accommodate their desire for upward mobility against a backdrop of complex class and caste structure on one hand and consumerist driven influences of the media and the west.

India has identified Housing as one of the eight national missions to reduce carbon emission as part of its commitment to reduce the vulnerability of the people to the impacts of climate change (NAPCC, 2008), this bottom-up approach to identify the sustainable strategies acknowledging people's needs and aspirations should be a useful contribution to achieving carbon reduction and sustainable housing.

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Automobile Engine Waste Heat Recovery and Possible Utilization- 1. Water Distillation & 2. Water Heating

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Abstract:

This is a proposal of a system to recover and use some of the automobile engine waste heat. Two-thirds of the fuel energy used in automobile engines is lost as heat to the atmosphere. Appreciable percentage of up to 80% of this heat can be recovered. This waste heat can be used to produce fresh water scarce in many regions of the world by a desalination process or to support everyday requirements of the domestic hot water. Finding other uses such as space heating in cold regions can minimize the mismatch between the domestic needs and the availability of the recovered heat. A lab test on a small petrol engine produced about 0.7L/h distilled water per kW engine power output and heated 10 L of water to boiling in less than one hour at 2.0 kW output.

1. Introduction

Energy is one of the most valuable commodities today. The twentieth century can be named as the energy century. Energy has become the driving power behind industrial growth and prosperity of those countries that have had early and abundant supplies of energy available. In many instances, the availability of low- cost energy has led to inefficient or excessive utilization and a gradual but sensible damage to the world environment. However, it is obvious that to improve the living of the majority of the world population, the present rate of energy consumption have to be further expanded. During the past three decades, there have been great efforts to use energy more efficiently with the development of more efficient automobiles, better insulation and control in buildings, co-generation…etc. Positive too is the people of the energy-dependent countries of the world are becoming more aware of the importance of efficient conversion and conservation of energy along with the development of new sources of energy. Therefore with all advances in the energy efficient systems, there is also a growing awareness to conserve conventional sources and to finding new less pollutant sources of renewable energy.

Yet for more than a century, since the internal combustion engines were introduced, we have been extremely careless about enormous amounts of energy that every one of us who runs a car is wasting every day. Twice the amount of the energy that takes the car around is being wasted as heat to the atmosphere. As much as 80% of this heat is recoverable in stationary engines. In automobiles the reason usually given is that these machines are in continuous motion and there is no easy or practical way to utilize this energy. The present practice or habit will remain as long as a cheap fuel (oil) is available, but the increasing world demand on energy is likely to impose an end to this waste.

As and when the energy conservation and pollution control are taken seriously, the engine waste heat recovery pose no technical challenge in its utilization for water distillation or domestic needs of hot water and space heating. The proposal can then be a solution for scarce fresh water in many regions and will perhaps eventually impose itself in domestic water heating too.

2. The Waste Heat Recovery System

In order to appreciate the energy conservation of the proposed system, some related information and facts are first presented.

2.1. Energy Sources and Consumption

It is interesting to examine as an example the primary sources of production and consumption of energy in the United States [1] in 1986 and for 2008 (Wikipedia), the distribution is as shown in Table 1.

Table 1 The production and consumption of energy in the United States

(Year)	(1986)	(2008)
Energy production by type of fuel		
Petroleum	43.1%	37.0%
Coal	23.4%	22.5%
Gas	22.4%	23.8%
Nuclear	6.5%	8.5%
Hydroelectric	4.3%	7.3%
& Other	0.3%	
Energy consumption by economic sector		
Electricity	36.3%	40.1%

Transportation	27.0%	27.8%
Industrial	21.6%	20.6%
Residential	15.1%	10.8%

These percentages will vary for different countries according to the size of industry, standard of living and availability of energy. Note the high percentage of energy (27%) consumed by transportation in the United States. This sector is the objective of the present proposal for energy conservation in support of the residential sector. The residential consumption covers domestic hot water, space heating, cooking and lighting.
Also relevant to the proposal is the knowledge of the average daily consumption of hot water. In domestic water heating studies, the consumption usually considered adequate is 50 liters per person per day. The consumption in the United States may be as much as 75 liters per person per day [2]. In general, a nominal hot water load of 250 liters per day is considered adequate [3, 4 & 5] for most families. Drinking water consumption of 3-5 liters per person is satisfactory in many regions of the world.

2.2. Automobile Engines Facts and Characteristics

Reciprocating internal combustion engines, ranging in size 5kW to 40000 kW, have successfully been used for direct drive of compressors, heat pumps, fans, pumps, electric generators, ships and most commonly to drive motor cars, private and commercial. These engines are relatively efficient, 25% to 35% of the input energy is converted to useful mechanical power. The remaining energy is transformed into heat, which must be removed from the engine.
The rejected heat can be recovered and used to support some thermal requirement as in cogeneration applications in stationary units. Figure 1 depicts the energy balance for a typical reciprocating engine. The majority of the engine heat is rejected in the engine exhaust (about 30%) and a similar percentage or more by the engines jacket water coolant. Smaller fractions of heat are rejected by lubrication oil and by radiation from the hot engine surfaces.

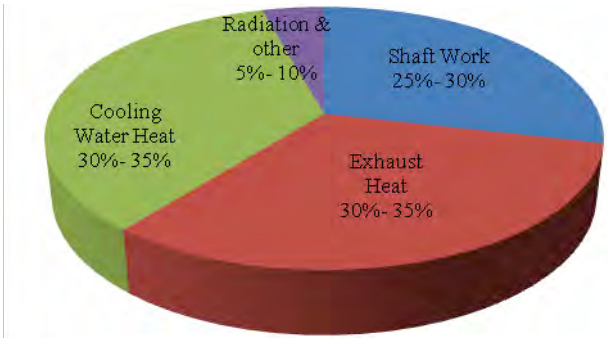

Fig. 1 Reciprocating engine energy balance

In stationary engines, almost 100% of the heat removed by the jacket cooling water is recoverable. The limitation on engine coolant temperature limits the temperature of the recoverable jacket heat. This heat can be used for domestic water heating, space heating and for various industrial processes.
The second major source of waste heat is by exhaust gases where temperature range from 200^{o}C to over 700^{o}C can be used to produce higher temperatures than from jacket coolant. However the exhaust heat recovery is limited by condensation problems in the heat exchanger where temperatures should not drop below 200^{o}C or special materials must be used. A general rule of thumb is that approximately 50% to 60% of the exhaust heat is readily recoverable. Table 2 gives the range of exhaust gas temperature as a function of engine type and operating conditions [6, 7].

Table 2 Exhaust gas temperatures in automobile engine

Engine type	Exhaust gas temperature	Operating condition
Spark-Ignition (Petrol)	400°C -600°C 300°C -400°C Up to 900°C	Medium load Idle Maximum power
Compression-Ignition (Diesel)	200°C-500°C	Medium load

The given temperatures are in the exhaust system, which are about 200°C cooler than the temperature at exhaust valve opening, due to expansion cooling. These temperatures drop by further 100°C-200°C at system's outlet due to the heat loss from the exhaust pipe and silencer.
In general, reciprocating engines are the only efficient, commercially proven technology that is available in sizes of a few hundred horsepower or less.

2.3 The Proposed Energy Saving Systems and Purpose

The engine waste heat is carried out both by the exhaust gases and the engine jacket cooling water. The jacket water heat is completely recoverable with some modifications. Considered now is the exhaust gases heat which requires less modifications. This heat can be utilized for the following purposes:

2.3.1. Water distillation

Essential for life is the fresh water scarce in many parts of the world and an application of the car engine waste heat can be as a source of process heat for evaporation in water distillation.
Different types of desalination systems and procedures are available making use of different sources of heat (fossil fuel, power plant waste heat, solar, Diesel or gas generator waste heat…etc). The multi effect humidification (MEH) method used in large plants, is also applied for small-scale production (0.5-2 cubic meters/day). This is suited for decentralized stand alone systems as it is nearly maintenance free [8]. It can be run either by solar energy or by waste heat from a diesel or gas generator.
A small direct heating distiller unit (10-20 Liter) can be designed for use on car engine waste heat. Such units can provide a family with its daily needs of fresh water in rural areas. These systems can be in demand in the Arab-peninsula, North Africa and elsewhere.

2.3.2. Domestic water heating

Hot water is required for direct use in every home throughout the day, all year round and indirectly for space heating in cold seasons. Most of this water can be obtained utilizing automobile's engine exhaust gases heat. A system consisting of an insulated tank fitted with a heat exchanger supplied with exhaust gases will be necessary. The tank (50-100 Liter) capacity may be placed in the car boot or facilitated in a modified car bumpers. Larger tank size (150-200 Liter) can be carried on a trolley provided with facilities for easy attachment to the car and designed for stability and safety. The heat transfer can be induced directly from hot gases in a fire tube or using an intermediate fluid as oil circulating between exhaust gases and heated water. The tank and the heat exchanger can be designed according to conventional systems practice to absorb as much as 80% of the heat carried by exhaust gases. A well designed rubber tank fitted in a modified bumper can serve an additional purpose of shock absorbing in case of accidents.
A back-up system is necessary to transfer the heated water to the domestic water storage tank, a pump and a thermally insulated receiving pipe must be fitted in the house. A separate storage tank may also be necessary.

For space heating, the heating units can be of storage type and a higher heat capacity fluid may be used in the system. The storage type heating system will simplify the back-up equipment. Good thermal insulation is essential for the system in general.
Figure 2 shows a schematic diagram both for the distillation unit and the auto heat storage tank with a back-up domestic transport system.

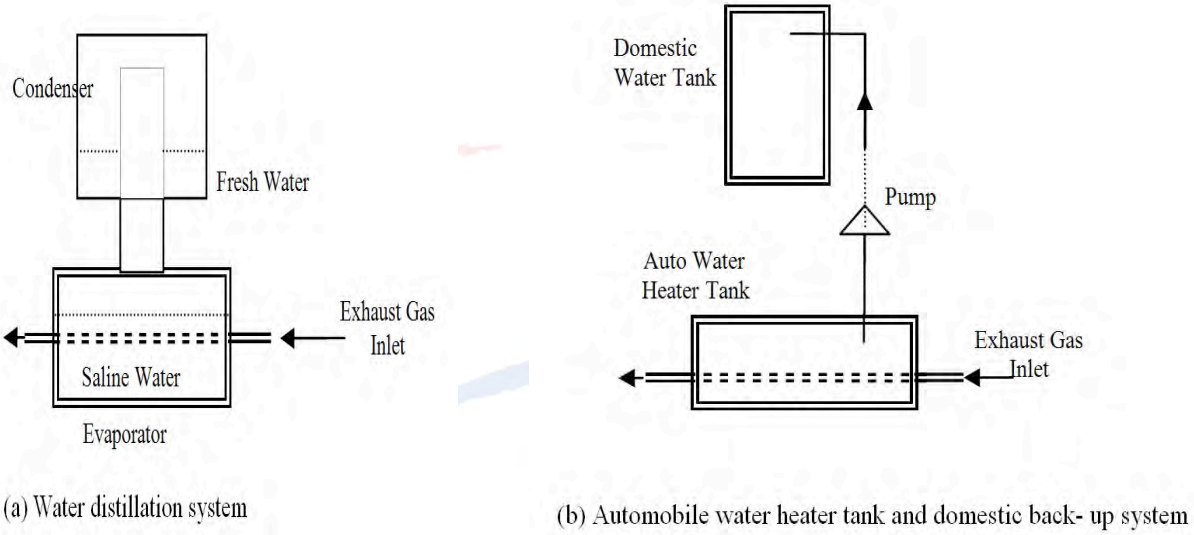

Fig. 2 Schematic diagrams of the heat recovery systems.

3. The Heating Capability of Automobile Engine Waste Heat

In stationary reciprocating engines plants almost 100% of the heat removed from the engine by jacket cooling water is recoverable and a portion of the exhaust heat can be economically recovered.
Considering the exhaust heat, and instead of going into the details of the heat transfer process between the exhaust gases and water used in conventional heat exchange systems, the performance of the proposed system can be evaluated more readily through some simplifying assumptions.
The available engine exhaust heat can be estimated by the fact that approximately one-third of the fuel combustion heat is carried away to the atmosphere by the exhaust gases. It can be assumed that 60% of this heat can be extracted in a conventional heat exchanger.

In an operating engine and on the basis of the consumption of 1.0kg (1.25 liters) of fuel having a heating value 45000 kJ/kg, the recoverable energy at 60% will be,

$$Q = \left(m_f \times HV \times \eta_{HE}\right)/3 = \left(4500 \times 0.6\right)/3 = 9000kJ \quad (1)$$

This amount of energy utilized as process heat has the capacity to:

1. Heat 50 liters of water through 43°C since,

$$Q = m_w \times c_w \times \left(T_{wh} - T_{wc}\right) \quad (2)$$

2. Produce no less than 3.5 kg of fresh water in a single-stage distillation apparatus suitable for small outputs. This is based on latent heat of evaporation and according to,

Condensed water (kg) = Heat transferred (kJ)/ Latent heat (kJ/kg)
Or

$$m_{cw} = Q/h_{fg} \quad (3)$$

In multi-effect-humidification (MEH) and distillation process, larger quantities of fresh water can be produced by the same heat quantity by reuse of condensation heat in several stages [9]. Attempts are made in developing multi-effect (ME) systems in small size too. However, the large quantities of car engine waste heat raise no problem in using the smaller direct-distillation systems that will be more suitable functionally and will be easier to fit on cars. Plans are made to design a water distillation system and perform experimental work utilizing actual motor car engine waste heat as process heat. It is also hoped that more work on the feasibility of these processes and systems to produce the precious fresh water in rural areas will be supported by research centers and relevant government establishments.

To acknowledge the amount of fuel that can be saved in conventional water heating systems when utilizing engine waste heat. Consider the daily hot water requirement for an average family. This varies from community to another, season to season and according to the overwhelming weather conditions. In Sydney-Australia [3], loads of 28-37 MJ/day were obtained from a survey of 1151 houses, and nominal tank capacities of 300 liters. In Maryland-U.S.A. [4], 30 MJ/day in summer and 38 MJ/day in winter with tank size of 250 liters are considered typical.

Considering the heating of 250 liters of water per day through 40°C, and then the daily required energy, neglecting the losses will be 41800 kJ. This amount of heat when provided by conventional systems, a certain amount of fuel will be consumed. These fuel quantities consumed can be saved when the above total heat is recovered from the automobiles exhaust gases. Note that this is possible during a ride where the fuel consumption adds up to 4.75 liters. Then the fuel saved will depend on the type of heating system used as shown in Table 3.

Table 3 Estimated fuel to be saved in conventional water heaters using Auto heat recovery.

Heating System for (250 Liter water, DT=40^{o}C)	Fuel Consumed or Saved (liters)
Automobile heat recovery system during a trip	4.75
Domestic oil fired heater (65% effectiveness)	2.0
Electric heater (Power plant efficiency 40%)	3.25

In most houses, due to the poor insulation, improper maintenance and excessive water use, the daily fuel consumption usually exceeds the values shown above.

In general there are large quantities of waste heat that can be recovered and made useful for domestic water heating or water desalination process. However, the additional weight of the motor car to perform the processes efficiently raises some questions on the feasibility of the system.

4. Practical Implementation of the Proposal

The first reaction on the proposal and especially for domestic water heating is expected to be negative to a great extent. This is not surprising when considering the present day low energy cost and the irresponsibility of damage caused to the environment. However being on the same side, there are many questions that may be raised against the practical implementation of the idea, these are:

1. The effect of the extra load carried on the car efficiency and on fuel consumption?

2. The heat losses from the water while on the car and when being transferred to the domestic storage tank?
3. The problem of integration of a water tank in a car with the domestic water system. Then the mismatch between hot water demands and the operation of a car can further reduce the effectiveness of such a system?
4. The cost of the system in relation to the value of additional hot water provided to homes?
5. Any loss of consumer attributes in the motor vehicle imposed by the additions of the system to the car?

The weight of the heat recovery system for water distillation or domestic heating is expected to range from 50 kg to 125 kg respectively including the process water. This extra weight makes about (5- 10) % or less of the weight of most saloon cars. This will cause a fuel consumption increase by an approximately the same percentage and again partially recoverable. However the extra weight is nearly equivalent to a passenger or two seated in saloon cars, then most cars usually moves partially empty in 80% of the time.

To evaluate system heat losses, the water carried in the car for storing the recovered heat will start losing heat as the temperature rises above the surroundings. Based on the use of 5 cm of typical insulation material for the tank and 2.5 cm for the piping, both calculations and laboratory tests produced the same results. The average heat loss at a temperature difference of $55^{o}C$ is no more than 20 W/m^2, causing an overall temperature drop of nearly $3^{o}C$ for 50 liters during five hours of time.

The transport process of water to the domestic tank will also cause a drop of temperature, both by heat transfer and thermal capacity of the system. Laboratory tests showed a decrease in temperature of $1.2^{o}C$ as water flow in 15-20 m of piping by heat transfer and an additional $3.5^{o}C$ as result of line thermal capacity. A further drop of about $3.0^{o}C$ is induced by the thermal capacity of the domestic water tank. The above estimated temperature drop may slightly increase or decrease according to the materials used, flow rate and time. Losses may sum up between 10% and 15%. The above estimates are directly proportional to the quantity of water carried in the car and increased quantities of the heated water can reduce losses.

The integration of the water tank on the car with the domestic system should not raise any major technical problems. The addition of a pump, insulated pipeline and valves could be built from available standard parts.

The major weakness of the proposed system could be in the mismatch between hot water demand and the car operation. The mismatch effect can be less harmful with larger families using larger water tanks or by alternative uses of heated water such as space heating in a storage type heating system, cleaning or other.

The large variation in the price of energy and also in the individual cost of manufacture of such systems, both complicates an accurate cost effective analysis. In Jordan as an example, the tank in the car fitted with heat exchanger and insulation can cost 200 to 300 US Dollars. The storage tank, the piping and the pump installation in the house for water transfer can cost another equal amount, adding up to about 700 Dollars. The fuel cost used for heating is around 0.6 Dollar/liter. The daily fuel use for average family could vary greatly and may exceed 5-10 liters according to installations quality, or annual accumulated fuel cost of 600-800 Dollars, mainly during the cold season (October to March). The car engine heat recovery system can provide 25% to 50% of the total heat. Considering 30% savings, (180- 250 Dollars), then the system could be paid off in four years. Never the less, the additional advantage in using the system will be the protection of the environment as result of less fuel consumed.

In regions where drinking water is scarce, the use of waste heat for water distillation could prove more valuable. The cost of a distiller up to 500 Dollars will be paid off in less than two years when producing 10 liters of water daily.

In general, adding a heat recovery system to an automobile for water heating or distillation will require some operation work and maintenance by the owner. Some loss of consumer attribute in

the motor car will arise but this will be acceptable when convinced in saving energy and protecting environment.

5. Discussion and Results

The importance of energy in every aspect of life is well known. Also the objectives of getting cheap energy, finding new sources and using energy more efficiently are becoming ever more challenging. In contradiction to these facts, we are still most careless about large quantities of heat energy wasted as is the case in automobile engines.

Reciprocating engines with efficiencies typically in range of 25% to 35% are the most efficient commercially available prime movers in smaller sizes. The majority of the engine heat is rejected in the engine exhaust and the engine jacket coolant. Almost 100% of the heat removed from the engine by jacket cooling water is recoverable while the exhaust heat that can be economically recovered is to less extent.

The stationary units are well-suited for cogeneration applications, such as space heating, domestic water heating and various industrial processes. With typical heat recovery, reciprocating engine cogeneration system can achieve overall efficiencies of 80%. The challenge now is to find the technology and applications to utilize automobile engine waste heat. The present proposal of using engine waste heat for water distillation do not raise obstacles and can prove to be a useful and successful application in many regions of the world. However the use of auto-engine waste heat for domestic water and or space heating will remain very much attached to the prices of the available energy.

As seen, there are large quantities of Up to 60% of exhaust gases heat and a similar percentage of engines cooling water heat of automobiles waste heat that can be recovered as useful heat. This when invested properly will be reflected positively on the budget of energy importing countries. Adding to this, the impact on the environment by the proposed system can be pronounced by reduction in oil consumption in power producing plants.

A test was arranged to make use of the exhaust heat from a small 5 kW, single cylinder (0.4 L), four-stroke petrol engine. A small 6.0 liter fire-tube boiler is fitted on the exhaust pipe. The condenser is made of five copper tubes (10 mm diameter, 1.5 m length each) leading steam from top of boiler to ambient conditions and down to a collection tank. The test results for different load conditions are shown in figure 3. At each engine load the thermal capacity of the system and that of the contained water required some time to reach the boiling state, this time decreased with increasing power as shown. There after the distilled water collected is proportional to the engine power output. The ambient condition during the test was 24^{o}C with a sensible natural draft and air motion in the laboratory. A simple calculation indicated that the boiler-condenser heat recovery effectiveness was only about 50%. The boiler was poorly insulated and can be designed to be more effective using an intermediate fluid such as oil for heat recovery [10]. The condenser too will be more effective on a moving car. The amount of distilled water per kW engine power output can be well above the test average of 0.7 L/ h.

Finally and on the verge of the 21st century, it is the responsibility of every person on the globe, and a greater responsibility of the governments to support and subsidize the application of such proposals. This will save valuable energy and can help to protect the environment.

6. Conclusion

1. A simple and available technology can be used to extract as much as 80% of the automobile engine wastes heat. This could be used for water distillation and for domestic water heating. The later application will need more work and time to be feasible.
2. A small water distillation unit for a family can be fitted to a motor car to produce fresh water by partial recovery of engine waste heat. Fresh drinking water scarce in many parts of the world can be produced from saline water. The design using available technology can be cost effective and requires minimum maintenance.
3. Engine waste heat recovery for domestic water heating whenever made practical can reduce fuel consumption in home furnaces saving valuable energy and reducing pollution. Increase in

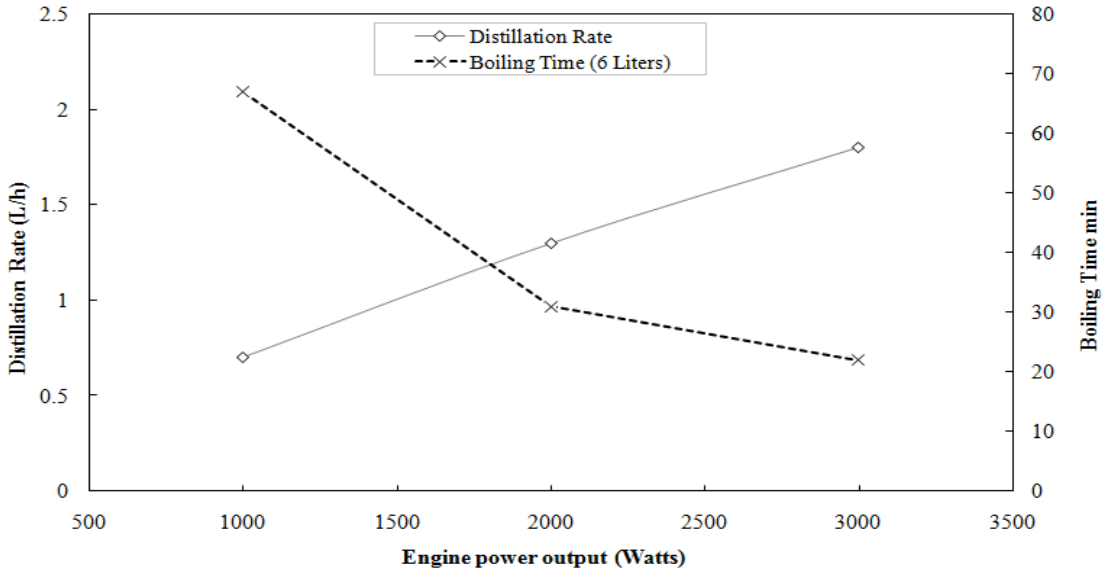

Fig. 3 Distillation Rate and Boiling Time as Function of Engine Power Output

energy prices will eventually impose this application.
4. The distiller evaporator or the water heater tank may be integrated as part of the future car bumper. This can save space and may have a safety characteristic acting as a shock absorber in case of accidents.
5. Some credibility of the car may be lost by adding these systems but this may be more than outweighed by energy cost savings and care of environment protection.
6. A test using a simple boiler-condenser unit showed that the recovered exhaust heat from a small engine can produce more than 1L/h distilled water per kW brake power and heat 10 liters of water from ambient temperature to boiling in less than one hour at 2kW engine output.
7. Protection of the environment is a challenge and a moral responsibility that needs worldwide cooperation and transparency in action. The industrial countries must bear greater responsibility.

Nomenclature

c	Specific heat (kJ/kg K)
HV	Heat value of fuel (kJ/kg)

h_{fg}	Latent heat of evaporation (kJ/kg)
m	Mass (kg)
Q	Heat load (kJ)
T	Temperature (°C)
h	Heat exchange effectiveness

Subscripts

c	Cold or Condensed
f	Fuel
h	Hot
HE	Heat Exchanger
w	Water

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The Future Environmental Risks Caused by Modern Antibiotics with Increasing Incidence of Severe Infections due to Multi-Resistant Bacteria in Humans

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Introduction

Many environmental studies focus on researching and assessing today's most common pharmaceuticals without having a forecast of consumption in the following decades. Modern and last resort antibiotics used for the treatment of severe bacterial infections caused by multi resistant bacteria are not subject to recent environmental risk assessments since they are rarely used today. As a result the environmental sciences lag behind the modern drug treatment and the achievements of pharmacology which leads to a delayed detection of environmental risks. Antibiotics previously approved only for special indications, e.g. ciprofloxacine, are sold in the magnitude of tons per years in many countries today (LANUV 2007). For these substances critical concentrations were met in nearly all environmental compartments (Kümmerer, Alexy et al. 2003; Santos, Araújo et al. 2010). Critical effects on water life was shown in numerous studies (Hanisch, Abbas et al. 2004).
The goal of this study is to evaluate the future environmental influence of the recent last resort-antibiotics Tigecycline, Linezolide, Daptomycine and the modern agents Rifaximin, Piperacillin and Doripenem. The main entrances, clinical and communal waste water were observed as well as the biodegradability in water and soil. All substances were applied to standardised ecotoxicological assays.

Material and Method

All selected last-resort antibiotics are used for the treatment of severe bacterial infections or other indications with dangerous ill patients. Linezolid is the first member of the new class oxazolidinone antibiotics, it is used for the treatment of complicated skin and skin structure infections (cSSSI), infections due to vancomycin-resistant enterococci (VRE) or hospital acquired pneumonia. Linezolid is available for intravenous application but also as tablet. The daily dosage is 1.2 g per day and patient (ZCT 2001). Tigecyclin is a glyclcycline antibiotic which is also used for the treatment of cSSSI, but also against complicated intra-abdominal infections (cIAI) and *Staphylococcus aureus* bacteraemia. Tigecyline should be applicated in dosages between 100 and 150 mg per day and patient (Geiss 2006). The first member of the new class cyclic lipopeptide antibiocics is Daptomycin, which can be used for the aforementioned infections as well as right-sided endocarditis. 350 – 500 mg should be given per day (ZCT 2006; Hair and Keam 2007). Furthermore we selected Piperacillin, an extended-spectrum ureido-penicillin, and Doripenem, a ultra-broad spectrum carbapenem (Janssen-Cilag 2011). Rifaximin is a rifamycin-based non-systemic antibiotic which was also included in the study.
A batch headspace test in closed bottles was used to test the biodegradability of the new substances in aqueous systems. A combination of two standard tests, after BODIS and ISO-CO_2-Headspace-Test, enables the determination of the biodegradability using the biological- and theoretical oxygen demand.
Each substance was tested in three parallels in comparison to sodium benzoate as good degradable reference and a blind value without degradable matter. The initial weights of the substances were calculated by the theoretical oxygen demand determined by elementary analysis. One gram standard German soil (LUFA 1.1 soil, Lufa, Germany) was used as inoculum. 700 mL of fresh prepared medium (after BODIS) was used in each bottle. All bottles were incubated for 28 days in a dark room with standard room temperature, stirred with a magnetic stirrer. The oxygen consumption and the carbon dioxide production was measured using GC-WLD (Perkin Elmer, Germany), calibrated before every measuring day with three calibration gases. The measuring was performed at days 0,3,7,14,21 and 28.

The test duration of the biodegradability-tests in soils was 120 days with 7 days of sampling during the period. 100 gram of German standard soil (LUFA 1.1, Lufa, Germany) was used as medium and inoculum. The measuring was executed with same sampling and the same GC-WLD as described above.

Three ecotoxicological assays were applied to the new substances following standard procedures. To evaluate the toxicity of the antibiotics to primary consumers a standardised 24-well-plate algae growth inhibition test was used (OECD 201, EG 440/2008). The test organism *Desmodesmus subspicatus* was exposed over 72 hours in a concentration series of every substance. The chlorophyll-fluorescence was measured every day with a TECAN SpectraFluorPlus photometer from first day on. *Daphnia magna* mobilisation inhibition assay (following ISO 6341) determined the toxicity to primary consumers. 1-day old crustaceans were exposed for 24 hours in 25 mL bakers to different concentrations of the target substances dissolved in demineralised water.
Vibrio fischeri luminescence inhibition assay (ISO 1138-1, 1998) was performed to evaluate the acute toxicity of the new antibiotics to destruents. A 30-minutes cuvette system with a LUMIStox luminometer (Dr. Bruno Lange GmbH, Germany) was used.
Lab scale reactors were used to test the effects and the efficiency of advanced oxidation processes to the new substances in pure water. Five methods or the combinations were applied: vacuum-UV-radiation, UV+H_2O_2, Ozonization, Ozonization+H_2O_2 and Ozonization+UV. For every target substance a start concentration of 20 mg/L was prepared and was treated for 30 minutes with every method. Samples were taken at the beginning and after 5,10,20 and 30 minutes. All samples were measured using ultra-performance liquid chromatography – mass spectrometry (UPLC-MS).

Results
Biodegradation of Linezolid, Piperacillin and Rifaximin is very poor (<10% within 28 days) in aqueous systems and poor for Doripenem (<30%) (Fig. 1). The biodegradation in soils shows a lag time of one month and started slow and constantly. Standardized algae growth inhibition test with *Desmodesmus subspicatus* showed increasing toxicity for Doripenem (EC_{50} = 1.8 mg/L) and Daptomycin (EC_{50} = 14.4 mg/L). Daptomycin showed acute toxicity to the destruent *Vibrio fischeri* (luminescence inhibition assay, EC_{50} = 95.8 mg/L). Linezolid caused an immobilization of *Daphnia magna* in 24h-acute toxicity test (EC_{50}= 160.4 mg/L) (Tab. 1).

As an exemplary result of two different transformation products of one origin substance we found with the treatment of Piperacillin with UV-radiation and the combination of H_2O_2 and Ozone. The usage of UV-radiation caused a specific breaking point and the production of a dioxipiperazin, whereas another method produced a thiazol carbocyclic acid.

The treatment of Daptomycin demonstrated the different efficiency of the advanced oxidation processes: The UV-radiation was unable to break down the target compound within the 30 minutes treatment, whereas the UV+H_2O_2-treament showed a complete degradation in the 10 minutes sample. Ozone seems to be strongest oxidizing agent since no original substance is present in the 5 minutes sample in all methods containing ozone-treatment.

Another exemplary result is of great concern showing a very stable transformation product. Linezolid was completely degraded after a few minutes, but the generated transformation product was insensitive to the selected treatment and is still present in the 30-minutes sample (Fig. 2). Until now we were not able to identify the molecule, in addition no information is known about its possible (eco-) toxicity or biodegradability in aqueous systems.

Conclusions

Severe infections caused by multi-resistant bacterial strains occur at increasing rates for some decades and a change of tendency is improbably. Not only the increasing incidence of dangerous infectious diseases itself but also demographic, socio-economic and health-economic factors may cause an increasing usage of new antibiotic drugs and last-resort antibiotics. Furthermore last-resort antibiotics with a possibility for oral substation, e.g. tablets, contain the danger of wide non-critical usage outside of hospitals. First results of eco-toxicological assays show effect concentrations of the new substances in the range of well-known older substances with identified relevance to environmental issues.
Just because new substances are not detected in sewage and surface water yet, because of their minor usage presently, does not mean they are environmentally irrelevant.
The effects of advanced oxidation processes to micro-pollutants have to be monitored in large scale reactors as the produced transformation products are partly very stable and not identified yet. The (eco-) toxicological influence of these new produced micro-pollutants is completely unknown.
Finally the responsible use of antibiotics or any other pharmaceuticals is not only an advantage for patients and economy, but also essential for the sustainable use of natural resources.

Outlook

All tests were performed with the substances in ideal conditions, in demineralized water. The results allow a first advice of environmental impact of the new substances, but the interaction of the substances among each other, with other micro-pollutants or sludge should be investigated as well. Furthermore the target substances of this study are all antibiotics for severe infections. Other major diseases (e.g. hypertonia, diabetes, cancer) are in change of therapy. More modern drugs have to be included in environmental studies.

Acknowledgements

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Tables

Table 1. Exemplary results of ecotoxicological tests

Substance	**Standardised Test System**	**EC_{50} [mg/L]**
Doripenem	Algae growth inhibition test *(D. subspicatus)*	1.8
Daptomycin	Algae growth inhibition test (*D. subspicatus)*	14.4
Linezolid	Immobilisation assay *(D. magna)*	160.2
Daptomycin	Luminsecence inhibition assay *(V. fischeri)*	95.8

Figures

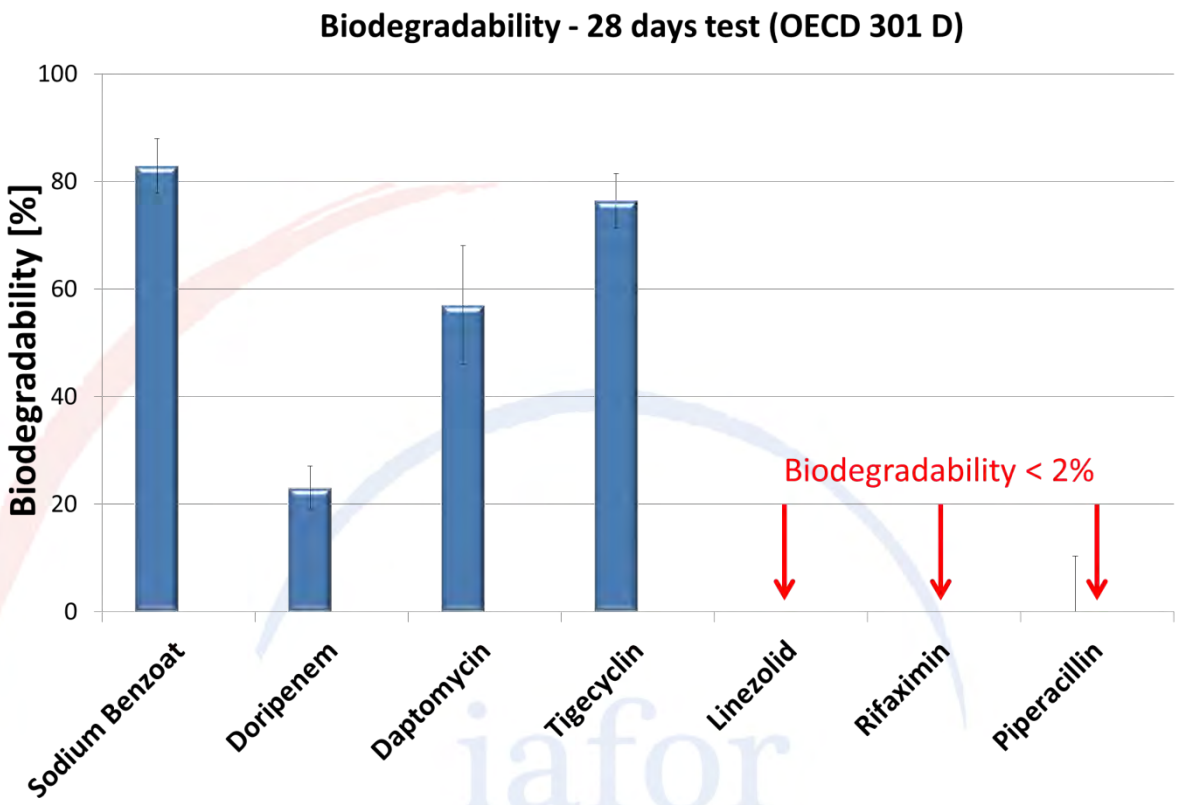

Fig. 1. Biodegradability of the new antibiotics (aqueous system, aerobic)

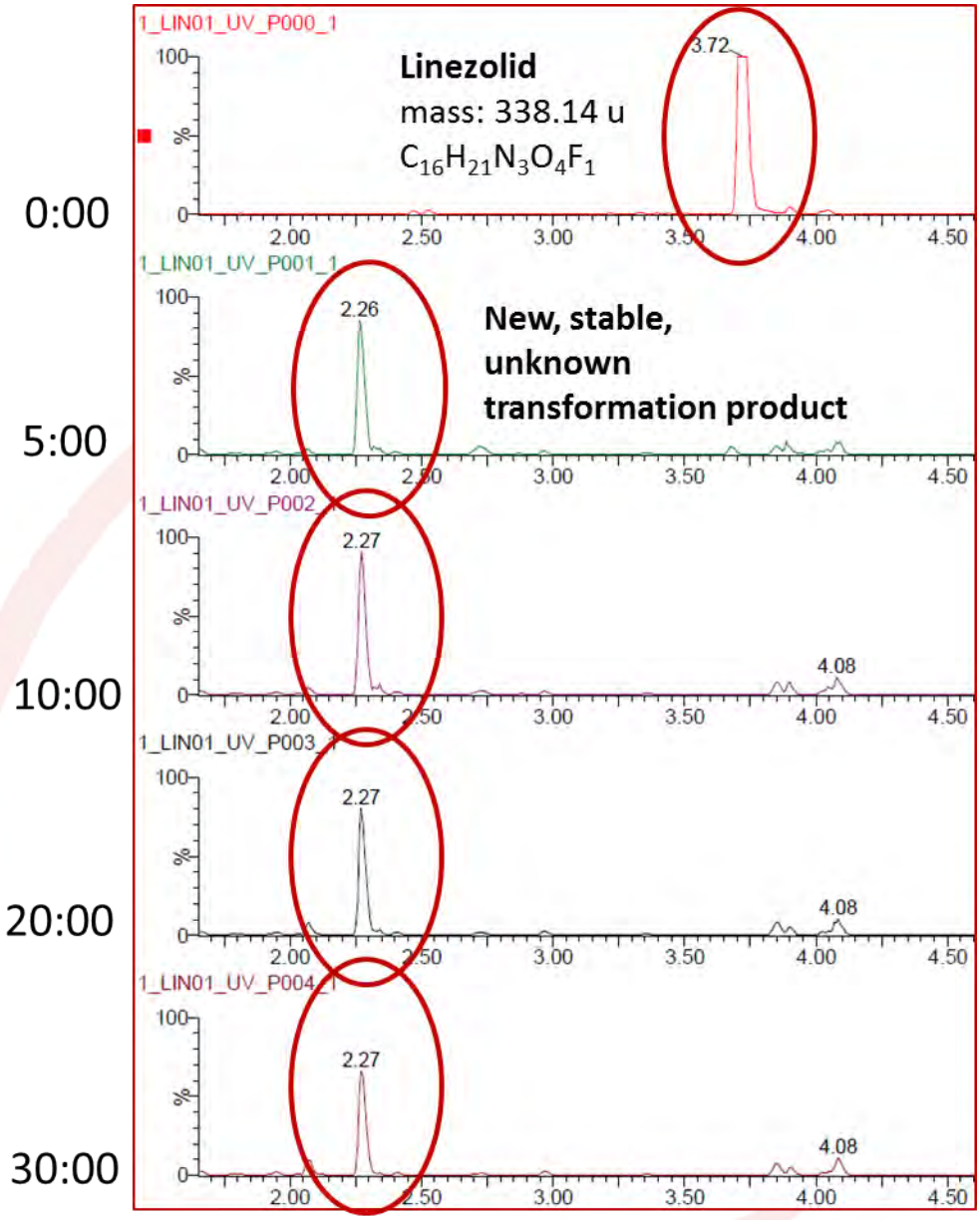

Fig. 2: Linezolid; treatment with UV-light. Startsample at 0:00 with original substance Linezolid, following samples with new peak at 2.27 min. indicating a new, UV-insensitive transformation product

The Relationship of Energy Consumption, CO2 Emission And Economic Growth: An Analysis For Thailand

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Abstract:

This paper aims to present the empirical investigation on the causal relationship among economic growth, energy consumption and CO2 emission in Thailand during the period of 1993 – 2010. The study framework based on Toda and Yamamoto (1995) approach. The findings from Granger causality found that an increase in GDP will bring about an increase in energy use, but not vice versa. Energy consumption causes the carbon emission in the long run and the inverse is also true. The increasing of energy use will make more CO2 emission. Carbon emission causes economic growth in the long run, but the inverse is not true. The response of LENR to LGDP is positive increasing trend after the quarter (one lag). But, the response to LCOE is nearly constant and last long over time. There is a strong relationship between LCOE to LENR, positive increasing trend on the response of LCOE to LGDP and initially positive impacts on response of LCOE to LGDP but decreasing over time. It implies that the effect of promoting low-carbon energy would be made some hinders on economic growth in short certain period and lesser impacts for long time in Thailand.

1. Introduction

Thailand experiences the high growth rates of economic during 1993 to early 1990 until the economic recession in 1997. During this period the economic growth rates of an average 8.04% per annum was gone with considerable highly increase of energy consumption and substantial CO2 emission at rates of 12.53% and 12.46%, respectively. Contraction in growth rates occurs in two periods. First was the period of 1997 – 1998 with average annum growth of -5.94%, 1.61% and -3.11% for economic, energy consumption and CO2 emission, respectively. Second was the period of 2008 – 2009 with average annum growth of 0.08%, 2.70% and 1.99% for economic, energy consumption and CO2 emission, respectively

However, as shown in Table 1, the period before crisis during 1994 – 1995 presents the high growth rate of real GDP, energy consumption and CO2 emission. The growth rate on energy consumption is declining over time while CO2 emission become structural adjusted with lower growth rate of 2.09%, 5.04% and 2.95% for the rest three periods (see Table 1). Moreover, notice that, CO2 emission become nearly steady growing rate over the periods. Figure 1 illustrates the increasing trends of real GDP and energy consumption that seem to be quite similar. Normally, the lower growth rates of total energy consumption over this period seem to reflect the lower economic activity and carbon emission. However, in the details perspectives, as shown in Figure 1, the trend of energy consumption and economic growth are not go along over time.

But, in the long run, the increasing patterns of gross domestic product and total energy consumption for Thailand for the period 1993–2010 are quite similar and closely related to each other, but CO2 emission is slower growth than the others.

Table 1. Energy consumption, CO2 emission and economic growth in Thailand.
(Average annual growth rates, %)

	Period			
	1994 - 1995	1996-2000	2001-2005	2006-2010
Real GDP	9.11%	0.64%	5.11%	3.62%
Energy Consumption	10.94%	4.35%	3.45%	1.74%
CO2 Emission	12.20%	2.09%	5.04%	2.95%

Notes: Author's calculation

Table 2. Oil import and consumption ratio (%)

	Period				
	1986 – 1990	1991 - 1995	1996 – 2000	2001 – 2005	2006 - 2010
Oil Import – Consumption ratio	54.49	56.52	63.12	62.43	63.45

Source: Energy Policy and Planning Office (2009) and author's calculation

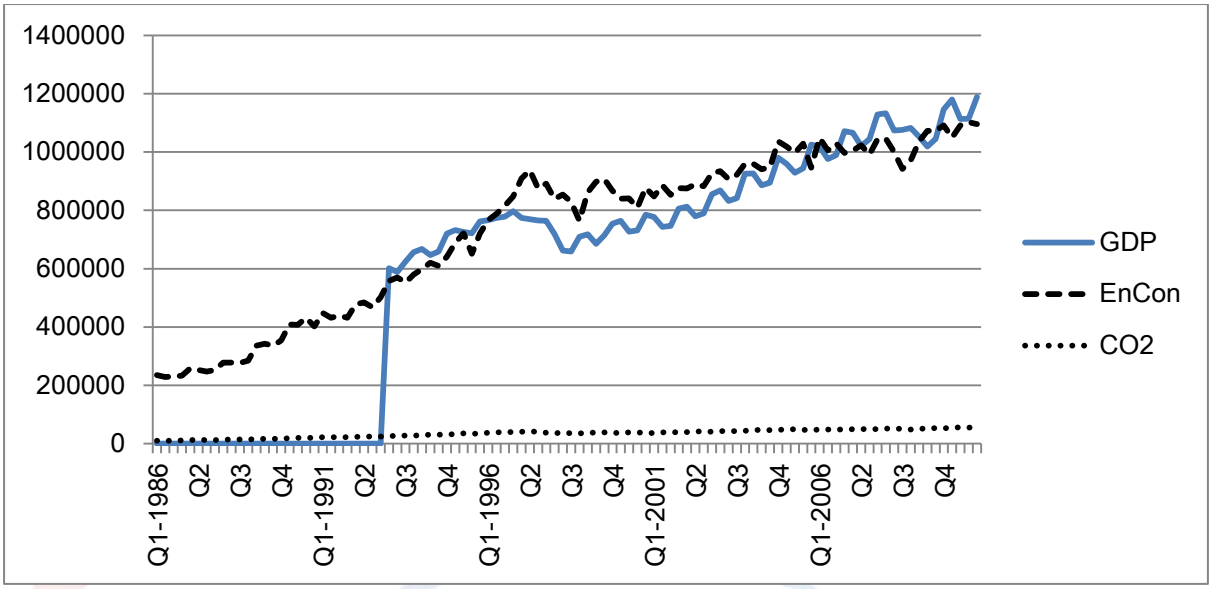

Figure 1. Quarterly growth trends of economic, energy consumption and CO2 emission in Thailand, 1993 - 2010.

Note: No quarterly data before 1993.

Actually, Thailand's economic has a high level of dependence on oil imports. It can be expressed from the ratio of oil import to consumption in Thailand. If the ratio present a high value, it means that the energy consumption is highly depends on oil import. Table 2 presents an average ratio in summary over the periods which are categorized in 5 years interval. This information provides us the ratio which is increasing from 54.49% in the period of 1986 – 1990 to 63.45% in the period of 2005 – 2009. During the period of 2003 – 2010, the ratio is increasing over time. Because the oil price in world market becomes highly volatile and the economic contracted in that period. This situation discourages oil consumption in great amount. Therefore, it reflects the higher dependence of energy consumption for economic growth in Thailand with having a linkage to carbon emission.

However, the concept regarding the relationship between energy consumption and economic growth are mentioned and analyzed in many studies. For example, Akarka and Long (1979) that presents on the concept of traditional neo-classical growth model and introduces energy as an intermediate input next to the basic factors of land, labor and capital contributing to economic growth. It is necessary to identify and understand the direction pattern of the cause-effect linkage among energy consumption, carbon emission and economic growth. This would make a great benefit for Thailand's energy policy implications. Moreover, since the presence of policies following the Kyoto protocol aiming at the reduction of energy consumption, it might possibly slow economic growth because of such causal relationships or the recent surge in the fuel prices. These issues have to be investigated the real relationship among variables.

This paper attempts to explore and investigate the causal relationship between energy consumption and economic growth in quarterly for Thailand for the period 1993–2010. The empirical investigation is conducted with the application of modified approach of time series proposed by Toda and Yamamoto (1995). The empirical focus has concentrated on the

impacts on each other among three variables: economic growth, energy consumption and carbon emission.

2. Methodology

The VAR and ECM is an empirical technique which is widely use to conduct the Granger causality that can examine the causal linkage and direction among variables. The VAR estimation can be conducted with first degree difference, namely I(1), of the variables. If the variables are known to be I(1) with no cointegration. It can be carried out the ECM approach. However, it needs to organize some pre-testing to identify the suitability because the ECM approach contains the bias. Moreover, another problem of this method is the basis assumption which is treated the time series as a stationary data. Therefore, this method has to be used in restriction scope and carefully to perform the estimation.

Tsani (2010) expresses that the limitations of the methodologies derive from the fact that an investigation of any cointegration relationships requires integration of order one (I (1)) of the series and any inference regarding relationship among variables is conditional on this assumption. If the series is not integrated of order I(1) or is integrated in different orders no test for long-run relationship is employed. On the other hand employment of unit root and cointegration tests may suffer from low power against the alternative therefore they can be misplaced and may suffer from pre-testing bias[1].

This paper applies the approach which is described in Toda and Yamamoto (1995). The major approach in this method is a modified Granger causality test to adjust the limitation of previous studies. In this study, it is an attempt to overcome the limitations of previous studies examining causal relationships between energy consumption, CO2 emission and economic growth and, then, to apply for the case of Thailand.

Furthermore, this approach applies a revised Wald test on the parameters of the VAR(k), where k is the lag length of the VAR system. The correction is performed on order of the VAR system by adding the maximal integration order (d_{max}) into the model. Then, the VAR($k+d_{max}$) is estimated with the coefficients of the last lagged d-max vector being ignored. Toda and Yamamoto (1995) affirms that the Wald statistic converges in distribution to an Chi-square random variable with degrees of freedom equal to the number of the excluded lagged variables regardless of whether the process is stationary, possible around a linear trend or whether it is cointegrated. Also, by using the approach, Zhang et al. (2009) explains that this approach does not require pre-testing in order to determine the cointegrating properties of the system hence overcoming potential unit root and cointegration test bias.

For this paper, the original VAR system model can be expressed, as follow.

$$V_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i V_{t-i} + \sum_{j=k+1}^{k+d_{Max}} \alpha_j V_{t-j} + \varepsilon_t \qquad (1)$$

where, α is a vector of constant, βt is coefficient matrix, and εt is white noise residuals. Where $\mathbf{V_i}$ is a vector of estimated variables consist of economic growth (LGDP), final energy consumption (LENR) and CO2 emission quantity (LCOE). All variables are in natural

[1] Zhang et al. (2009)

logarithm. These three variables are arranged in three pairs in VAR system to create investigating models. For example, to investigate the relationship of LGDP and LENR, the pair of equation can be derived and formed a model as follow,

$$LGDP_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} LGDP_{t-i} + \sum_{j=k+1}^{k+d_{Max}} \alpha_{2j} LGDP_{t-j} + \sum_{i=1}^{k} \gamma_{1i} LENR_{t-i} + \sum_{j=k+1}^{k+d_{Max}} \gamma_{2j} LENR_{t-j} + \varepsilon_{1t} \quad (2)$$

$$LENR_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} LENR_{t-i} + \sum_{j=k+1}^{k+d_{Max}} \beta_{2j} LENR_{t-j} + \sum_{i=1}^{k} \delta_{1i} LGDP_{t-i} + \sum_{j=k+1}^{k+d_{Max}} \delta_{2j} LGDP_{t-j} + \varepsilon_{2t} \quad (3)$$

As shown in Eq. (2), Granger causality analysis will be performed on $LGDP_t$ to $LENR_t$ for $\gamma_{1i} \neq 0$. On the other hand, in Eq. (3), Granger causality have to conducted from $LENR_t$ for all i and $\delta_{1i} \neq 0$**.**

After that, the others two pairs of equation, LENR_LCOE and LCOE-LGDP, are estimated in the same way as the example. Toda and Yamamoto (1995) procedure is used to examine the relationship among income, energy and environment aspects in Thailand. The steps are as follows[2]:

(i) Find the maximal order of integration d of variables by conducting unit root tests.
(ii) Identify the optimum lag length k of a VAR by several criteria such as AIC, SIC, HQ.
(iii) Estimate the lag-augmented VAR ($k+d_{max}$) model:
(iv) Check robustness of augment VAR ($k+ d_{max}$) by diagnostic tests.
(v) A Wald test is conducted on the first k parameters instead of on all parameters in the augment VAR ($k+d_{max}$) model and the statistics follows an asymptotic Chi-square distribution with k degrees of freedom[3].

3. Data and unit root tests

This study uses quarterly data on real GDP (Y) (constant price of 1988 and local Thai-Baht), final energy consumption (E) converting to oil equivalent; barrel per day and CO2 emission from energy consumption (kilo-tons). All data covering the period of 1993 to 2010 and are used in natural logarithm.

In order to investigate the existence of the Granger causality between energy consumption, CO2 emission and real GDP the first step should be the identification of the order of integration of the series under consideration (d_{max}). For this purpose a set of different unit root tests is employed. In order to derive the order of integration the Dickey and Fuller (1981) test (ADF) and the Phillips and Perron (1988) test (PPerron) are employed.

The unit root tests are necessary to be carried before conducting the estimation with Toda and Yamamoto (1995) method. The purpose is to obtain the maximum of integration order (d_{max}) in each variable. This study conducts three different unit root tests: augmented Dickey–Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS). All tests are

[2] Zhang et al. (2009)
[3] For more details on Wald statistics, see Toda and Yamamoto, 1995; Zapata and Rambaldi, 1997.

defined on the basis null hypothesis that I(1) has a unit root, and the results present mostly the rejecting null hypothesis at 1% statistical significant, except LCOE on intercept and trend.

Therefore, the results of unit root tests reported in Table 3 which indicated that the integration orders of all variables do not appear to be larger than 1, so d_{max} is defined as 1.

Table 3. Results of unit root test

Variable	ADF test		PP test		KPSS test	
	In	In + Tr	In	In + Tr	In	In + Tr
Levels						
LGDP	-0.4502 (5)	-2.0827 (5)	-0.6933	-3.1157	1.0723[a]	0.1432[c]
LENR	-2.2444 (0)	-2.9744 (0)	-2.5740	-2.7519	0.9754[a]	0.1627[b]
LCOE	-1.0926 (6)	-2.8197 (6)	-1.9299	-3.3498[c]	1.0663[a]	0.0722
First differences						
LGDP	-3.5584[a] (4)	-3.5300[b] (4)	-8.1063[a]	-7.9804[a]	0.1196	0.1183
LENR	-10.5550[a] (0)	-10.6688[a] (0)	-10.8430[a]	-11.4023[a]	0.2427	0.1122
LCOE	-3.7009[a] (5)	-3.6472[b] (5)	-8.6488[a]	-8.6612[a]	0.1569	0.1054
Second differences						
LGDP	-5.4117[a] (3)	-5.3623[a] (3)	-15.2311[a]	-15.3817[a]	0.1047	0.1005
LENR	-8.6849[a] (3)	-8.6157[a] (3)	-49.2580[a]	-47.6054[a]	0.1591	0.1589[b]
LCOE	-13.9908[a] (2)	-13.9211[a] (2)	-21.3862[a]	-21.2193[a]	0.1387	0.0779

Note:
1. In means intercept, and In+Tr means intercept and trend.
2. Superscript a, b and c denote as a significant level of 1%, 5% and 10%, respectively.
3. For ADF test the lags are based on the Schwarz information criteria (SIC) with maximal lag = 11. The critical values for the ADF test t statistics are from MacKinnon (1991).
4. PP test with automatic lag selection based non Newey-West (1994), lags=3 and the critical values for the KPSS test are from Kwiatkowski et al. (1992).

4. Empirical Findings

Table 4 presents the correlation among real GDP, energy consumption and economic growth in Thailand. The finding suggests that developments in economic growth, energy consumption and CO2 emission patterns are strongly correlated. All correlation coefficients are positive and indicate the same direction adjustment among these three variables. By comparing on coefficients value, the energy consumption has greater impact to CO2 emission than the economic growth. However, both economic growth and energy consumption greatly activate to CO2 emission in Thailand. Moreover, the economic growth and energy consumption are also highly correlated each other, even though lesser than theirs relationship to CO2 emission.

Regarding the information presented, the correlation is just illustrated the natural pattern of causal relationship among variables. Despite the lack of causal direction, the correlation provides as preliminary information and leads as a guideline for identifying causal direction.

Table 4. Real GDP, Energy consumption and CO2 emission – Correlation matrix

	LGDP	LENR	LCOE
LGDP	1		

LENR	0.8465	1	
LCOE	0.9386	0.9458	1

4.1. Causality tests

In Toda and Yamamoto (1995) approach, firstly, it needs to determine the optimal lag length. The several tests are conducted for identifying the optimum lag length such as Akaike Information criterion (AIC), Schwarz Information Criterion (SIC) and Hanna-Quinn information criterion (HQ) and the results are shown in Appendix.

For the first pair of equation, LGDP-LENR, the optimal lag length is pointed out by AIC and FPE equal to 7, LR and HQ suggests a lag length of 6, while the optimum lag length of VAR is 3 via SIC. Then, the diagnosis tests on augmented model, VAR ($k+d_{max}$), are conducted to identify the stability condition. The diagnosis test is performed through the inverse roots of the characteristics autoregressive polynomial. The estimated VAR is stable (stationary) if all roots have modulus less than one and lie inside the unit circle. If the VAR is not stable, certain results (such as impulse response standard errors) are not valid.

The diagnostic test results indicate the augmented VAR (4) ($k+d_{max}=4$) is not stable. But the results of VAR (7) ($k+d_{max}=7$) and VAR (8) ($k+d_{max}=8$) are stable. However, as suggested by Stock (1994) in the case of conflicting results between the different tests, AIC is preferred above other tests. Therefore, in the first pair of equations, the VAR (8) ($k+d_{max}=8$) is chosen to analyze in the next process.

Similarly, the second pair of equations is carried out in the same way. The LENR-LCOE optimal lag length is pointed out by AIC, LR and FPE equal to 7, while the optimum lag length of VAR is 3 via SIC and HQ. The diagnostic test results indicate the augmented VAR (4) ($k+d_{max}=4$) is stable. Unfortunately, the results of VAR (8) ($k+d_{max}=8$) is not stable. Therefore, the VAR (4) ($k+d_{max}=4$) is chosen to analyze in the next process.

For the third pair of equations, the LCOE-LGDP optimal lag length is pointed out by AIC and FPE equal to 7, while the optimum lag length of VAR is 5 via SIC, HQ and LR. The diagnostic test results indicate both augmented VAR (6) ($k+d_{max}=6$) and VAR (8) ($k+d_{max}=8$) are stable. Therefore, the VAR (8) ($k+d_{max}=8$) is chosen to analyze in the next process.

Table 5. Granger causality test

From	To	F statistics	Lag	p-value	Causality
GDP	ENR	1.8728	8	0.0871	GDP --> ENR *
ENR	GDP	1,2128	8	0.3124	No
COE	ENR	4.5554	4	0.0028	COE --> ENR ***
ENR	COE	5.1410	4	0.0013	ENR --> COE ***
GDP	COE	1.5337	8	0.1713	No
COE	GDP	2.5278	8	0.0224	COE --> GDP **

Note:
1. ***, ** and * denotes as a significant level of 1%, 5% and 10%, respectively.

Results in Table 5 show that there is a unidirectional Granger causality running from real GDP to energy consumption at the 10% significant level in Thailand. That is, an increase in GDP will bring about an increase in energy use, but not vice versa. Therefore, Thai government can foster conservative energy policy in the long run without retarding economic growth. This result is the same as Zhang et al (2009), but differs from the study of Yuan et al (2008).
The second finding in Granger causality is that energy consumption causes the carbon emission in the long run and the inverse is also true in Thailand. This is a reinforcing loop between energy using and carbon emission in Thailand. The more CO2 emission that makes unfavorable condition of environment will initiate the higher energy consumption. Also, the increasing of energy use will make more CO2 emission. Thai government may have a policy to encourage the using of low-carbon energy that means to impede high-carbon energy consumption and discourage CO2 emission.

Another important finding in Granger causality is that economic growth not directly causes the carbon emission in the long run. However, the inverse is true in Thailand. It can be explained that the general economic activities in Thailand are still inefficient in term of carbon generating and emission. Also, people may have an absence of environment awareness and concern.

4.2. Impulse response

Figure 2 shows the impulse response of the variables which represent a time of adjustment for each variable. Each curve presents the shock occurring on one variable impacts to another variables and illustrate how long the effect lasts in short run. The shock in one of three variables (LGDP, LENR and LCOE) mostly has positive initial impacts on the others, except response of LENR to LGDP.

The response of LENR to LGDP is initially minimal negative but in positive increasing trend after the quarter (one lag). But, the response to LCOE is nearly constant and last long over time. Furthermore, the response of LCOE to LENR is on decreasing trend over time. It also presents that the impact on LENR shock having positively last long for less than one year. This reflects a very closely relationship between LENR and LCOE. Another important finding is the positive increasing trend on the response of LCOE to LGDP. Even though the LCOE has statistical insignificant cause to LGDP, the response curve illustrates the linkage between carbon emission from consumption activities impact to economic growth.

Lastly, the response curve of LGDP to LENR which represents an adjustment of economic growth to a shock of energy consumption is died off over horizontal after 10 lags or 30 months. Notice that, the response starts with positive value at the first time, increasing for 6 months and declining for another 6 months. It reflects the length of one year on positive impact of energy consumption shock on economic growth. After that the negative response occurs and last long for about 18 months.

Another important finding is that a response of GDP (LGDP) on shock of carbon emission (LCOE) has initially positive impacts on economic growth but decreasing over time at the end. All of these results of impulse response analysis support that of Granger causality tests. It is interesting to note that impacts of carbon emission shocks on economic growth are decreased over the horizons, although initial impacts are greatly positive. It implies that the

effect of promoting low-carbon energy would be made some hinders on economic growth in short certain period and lesser impacts for long time in Thailand.

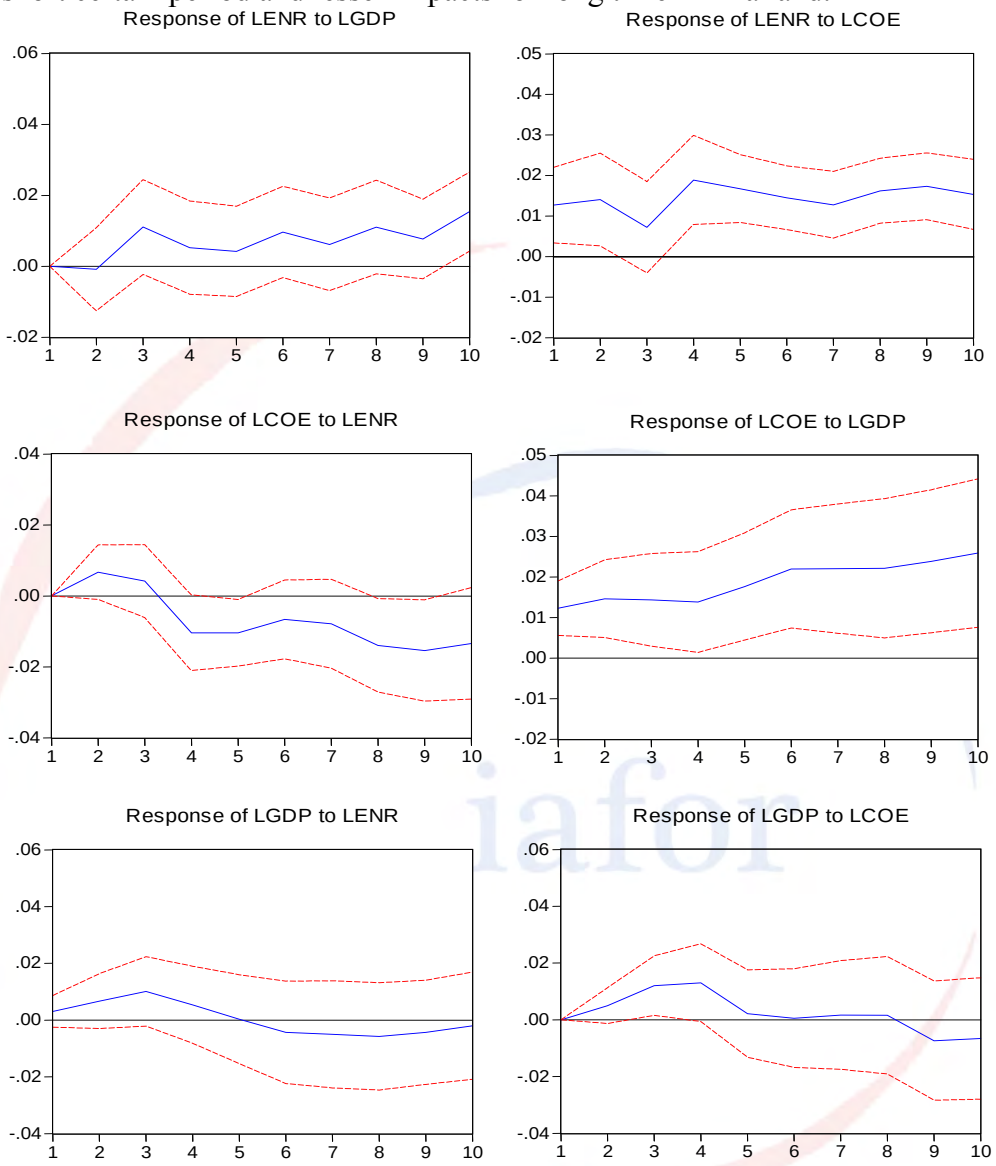

Figure 2. Impulse response function for economic growth, energy consumption and CO2 emission in Thailand.

The Wald statistic is conducted for lag exclusion tests in each lag in the VAR. For each lag, the Wald statistic for the joint significance of all endogenous variables at that lag is reported for each equation separately and jointly. For LGDP-LENR equation, the findings summarizes that the only lag no. be excluded from the model are lag 3 and lag 6 with significant level of 10%. For LCOE-LENR equation, the findings summarizes that there is only lag no. 2 being excluded from the model with significant level of 10%. Finally, For LCOE-LGDP equation, the findings summarized that the only lag no.2, 3, 7 be excluded from the model with significant level of 10%.

5. Conclusion and policy implications

This paper investigates the temporal linkages among GDP, energy consumption, and carbon emissions Thailand during the period 1993–2010 in a multivariate model. By using the Toda and Yamamoto (1995) model and quarterly data, the empirical findings on Granger causality illustrates that the changes in economic growth will directly impact to energy consumption, but not in the contrary.

Energy consumption positively causes the carbon emission in the long run and the inverse is also true in Thailand. The findings present the reinforcing mechanism on energy consumption and carbon emission which initiate unfavorable environment condition that, in turn, make greater energy consumption. Carbon emission has a positive linkage to economic growth in the long run. However, the economic growth does not encourage to CO2 emission in Thailand. It can be explained that economic activities in Thailand are mostly inefficient use of energy and make large amount of carbon emission, particularly in the long run.

The findings of impulse response functions present that the shock on increasing amount on energy consumption impacts to GDP by decreasing in minimal at the beginning one quarter and positively increase after that. The shock on energy consumption to carbon emission is nearly constant and last long over time. However, in the opposite, the response of carbon emission to energy consumption is on decreasing trend over time. It reflects a close relationship between energy consumption and carbon emission. There is a positive linkage between carbon emissions from consumption activities impact to economic growth. The adjustment of economic growth to a shock of energy consumption is died off over horizontal after 30 months and on relationship in the long run. The impacts of carbon emission shocks on economic growth are decreased in the long run.

It implies that the effect of promoting low-carbon energy would be made some hinders on economic growth in short certain period and lesser impacts for long time in Thailand. Also, the increasing of energy use will make more CO2 emission. Thai government may have a policy to encourage the using of low-carbon energy that means to impede high-carbon energy consumption and discourage CO2 emission. The dominant source of carbon emission is energy consumption activities not economic activities. Policies diversifying energy source may be applied to reduce the reliance on fuel that normally in consumption activities such as oil. Thailand should promote to increase the utilization of clean energy fuel such as wind, solar and bio energy.

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7. Appendix

Table A1. VAR lag order selection criteria: LGDP and LENR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	108.9475	NA	0.000115	-3.395157	-3.327121	-3.368398
1	220.6396	212.7469	3.77E-06	-6.813955	-6.609847	-6.733679
2	223.4568	5.187257	3.91E-06	-6.776407	-6.436226	-6.642612
3	249.7859	46.80731	1.93E-06	-7.485267	-7.009015*	-7.297955
4	252.7288	5.044881	2.00E-06	-7.451707	-6.839383	-7.210877
5	263.3019	17.454	1.63E-06	-7.660377	-6.91198	-7.366029
6	271.7339	13.38419*	1.42E-06	-7.801076	-6.916608	-7.453211*
7	276.7272	7.608863	1.39e-06*	-7.832610*	-6.81207	-7.431227
8	278.573	2.695367	1.50E-06	-7.764221	-6.607609	-7.30932
9	279.7573	1.654362	1.65E-06	-7.674836	-6.382152	-7.166417

Note: * represents lag order selected by the criterion with choosing the maximum lag length of 9.

Table A2. VAR lag order selection criteria: LCOE and LENR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	135.1051	NA	5.01E-05	-4.225559	-4.157523	-4.1988
1	234.6961	189.6971	2.41E-06	-7.260193	-7.056085	-7.179916
2	240.145	10.03293	2.30E-06	-7.30619	-6.96601	-7.172396
3	252.1927	21.41811	1.79E-06	-7.561672	-7.085420*	-7.374360*
4	255.3415	5.398058	1.84E-06	-7.534652	-6.922328	-7.293822
5	260.8424	9.080771	1.76E-06	-7.582298	-6.833902	-7.28795
6	261.1624	0.508004	1.99E-06	-7.465474	-6.581006	-7.117608
7	269.2298	12.29310*	1.76e-06*	-7.594596*	-6.574056	-7.193213
8	271.8969	3.894897	1.85E-06	-7.552284	-6.395671	-7.097383
9	274.1178	3.102122	1.98E-06	-7.495802	-6.203118	-6.987383

Note: * represents lag order selected by the criterion with choosing the maximum lag length of 9.

Table A3. VAR lag order selection criteria: LGDP and LCOE

Lag	LogL	LR	FPE	AIC	SC	HQ
0	124.5109	NA	7.01E-05	-3.889236	-3.8212	-3.862477
1	247.2235	233.7383	1.62E-06	-7.65789	-7.453782	-7.577613
2	256.2819	16.67896	1.38E-06	-7.818474	-7.478294	-7.68468
3	286.7073	54.08957	5.97E-07	-8.657375	-8.181123	-8.470063
4	290.9128	7.209397	5.94E-07	-8.663898	-8.051574	-8.423068
5	306.4692	25.68043*	4.13E-07	-9.030769	-8.282372*	-8.736421*
6	310.6725	6.671806	4.13E-07	-9.037221	-8.152752	-8.689355
7	315.4046	7.210916	4.06e-07*	-9.060464*	-8.039924	-8.659081
8	315.8433	0.640644	4.58E-07	-8.947407	-7.790795	-8.492506
9	316.68	1.168752	5.12E-07	-8.846985	-7.554301	-8.338566

Note: * represents lag order selected by the criterion with choosing the maximum lag length of 9.

An Optimum Control Strategy for Energy Management in a Remote Area Stand-Alone PV System

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The Asian Conference on Sustainability, Energy and the Environment

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Abstract:

This paper presents a new modified configuration for the stand-alone photovoltaic (PV) system, which consists, mainly, of a PV array and a storage battery; to electrify a remote area household load in Sinai Peninsula of Egypt. The paper presents, also, the modeling, simulation, and operational control strategy for the stand-alone PV system. Where, the developed control strategy aims to optimize the energy flow within the system, such that the load is satisfied, all over the day time, independent on the variations in environmental conditions. Also, the developed control aims to protect the global stand-alone PV system against the unexpected hazards, due to the unpredictable excess or deficit of the available energy. The simulation results led to a good realization of the operational control strategy.

1. THE SUGGESTED PV SYSTEM

The block diagram of the suggested PV system, in this work, is shown in Fig. 1. This system can be described as autonomous system, which can supply electricity to the remote area household load without being connected to the electric grid [1-4].

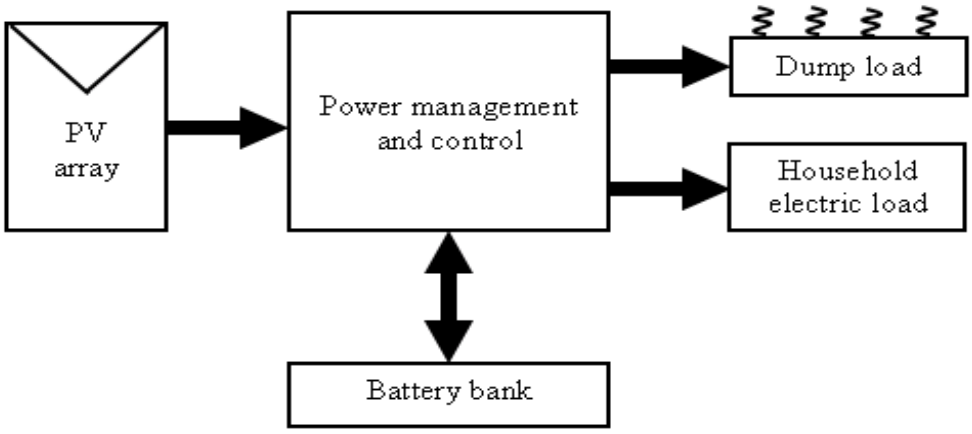


Fig. 1 Block diagram of the suggested PV system.

The power management and control unit is used to optimally control the management of the energy flow within the overall system, and to match and protect its components. The dump load is used, in this work, to guarantee the proper functioning of the suggested PV system, where it is used to consume the surplus energy generated by the system.

The schematic diagram of the considered stand-alone PV system is shown in Fig. 2. Where, the PV array is considered to be the only source of the required electrical energy in the system, and the battery is the storage medium. Therefore, the considered stand-alone PV system must be carefully sized to continuously supply the required electrical power to the household electrical load.

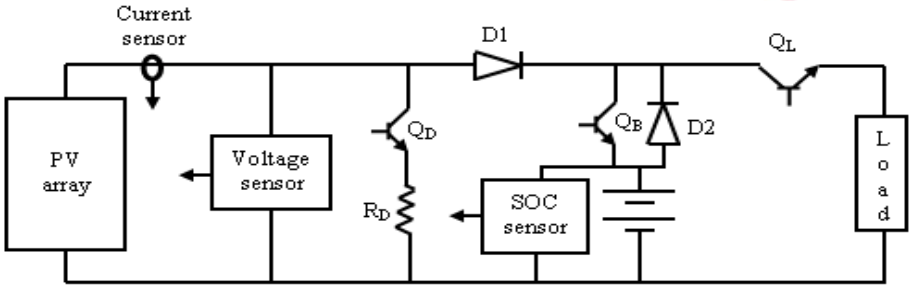


Fig. 2 Schematic diagram of the stand-alone PV system.

2. STAND-ALONE PV SYSTEM MODELING

2.1 The PV Array

The PV array has a nonlinear current-voltage (I_{PV}-V_{PV}) characteristic, which can be described as [5]

$$I_{PV} = I_{Ph} - I_{os}\left[\exp\left(\frac{eV_{PV}}{nTK}\right) - 1\right] \quad (1)$$

Where, I_{Ph} is the photo-current, I_{os} is the reverse saturation current, n is the ideality factor, K is the Boltzmann's constant, e is the charge of electron, and T is the PV cell absolute temperature

2.2 The Battery

The relation between the battery voltage V_B and current I_B during the states of discharging and charging can, respectively, be described in terms of the battery ampere-hour rating AH and state of charge SOC of the battery by the following two equations [6].

$$V_B = V_r - \frac{I_B}{AH}\left(\frac{0.189}{SOC} + R_i\right) \quad (2)$$

and

$$V_B = V_r + \frac{I_B}{AH}\left(\frac{0.189}{1.142 - SOC} + R_i\right) \quad (3)$$

Where, V_r is the battery rest voltage, R_i is the battery internal resistance.

3. SYSTEM CONTROL AND SIMULATION

The main purposes of the designed control strategy are to satisfy the household electrical load and to safely discharge or charge the storage battery whenever possible. Also, the designed control aims to protect the global system from the unpredictable excess or deficit of the available energy. The designed control strategy, as shown in the flowchart of Fig. 3, is based on the IF-THEN rules; such that the IF-part of a rule represents the current state of the system, while the THEN-part represents the suitable-issued-control command of the system.

The suggested PV system is simulated, in this work, by using MATLAB-SIMULINK.

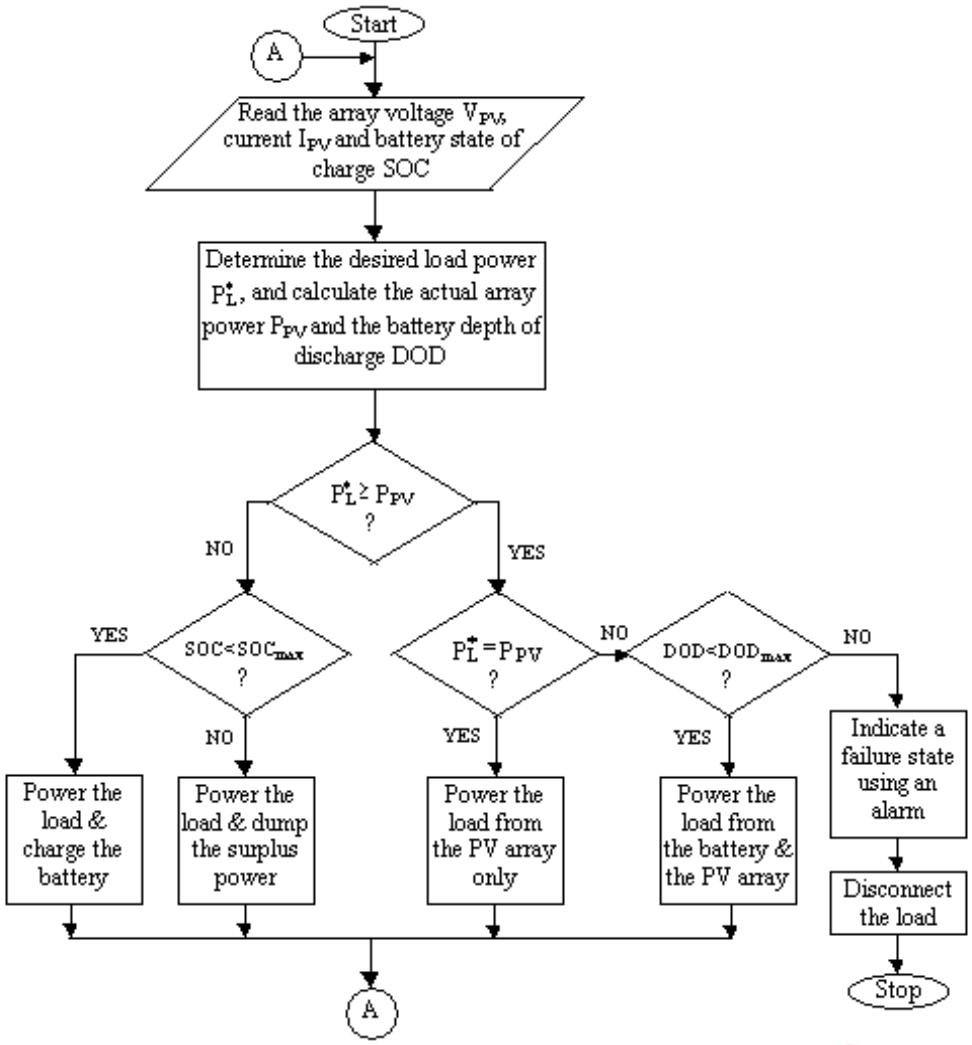


Fig. 3 Flowchart of the designed control strategy.

4. SIMULATION RESULTS

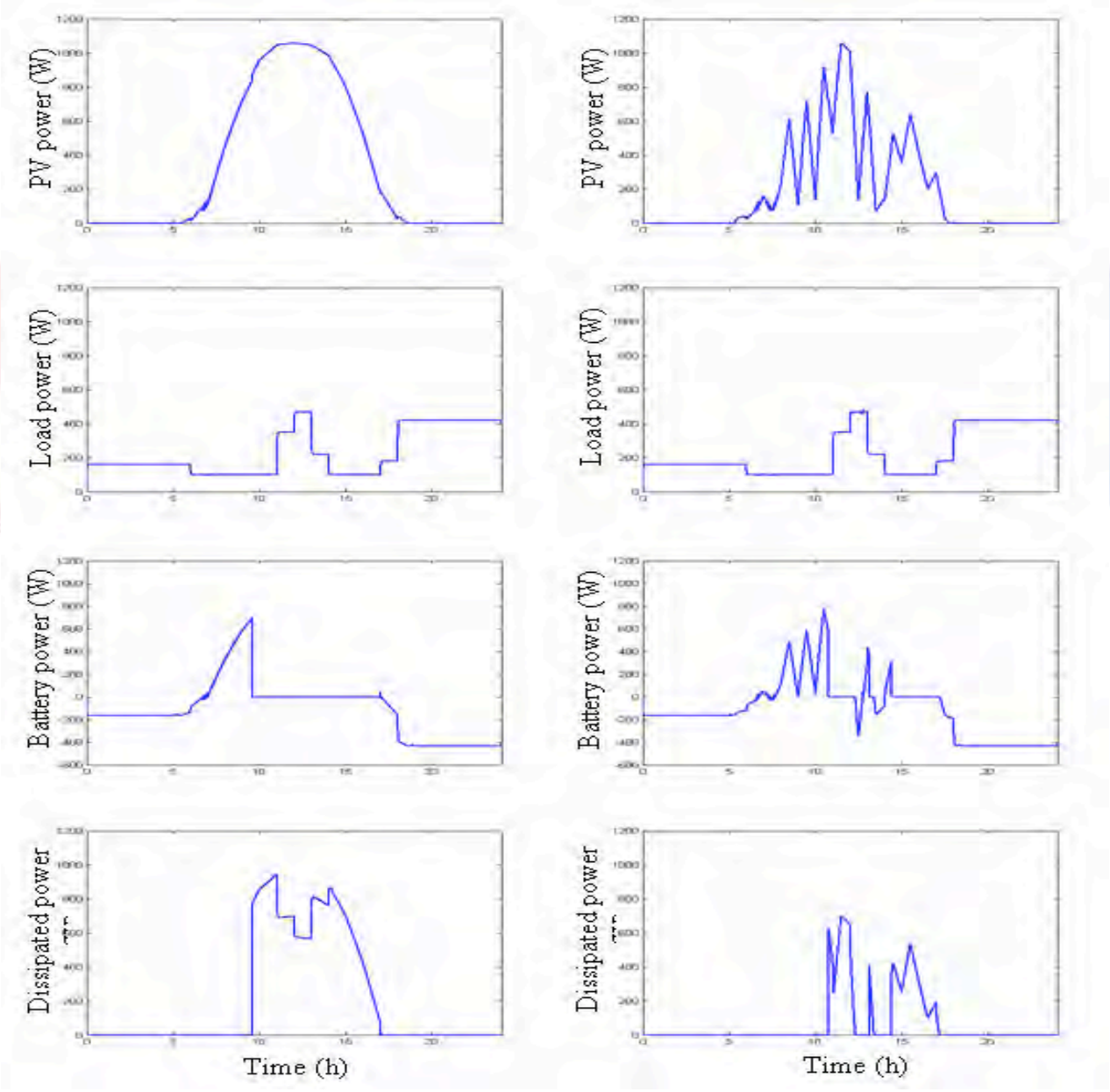
The results of the stand-alone PV system are best evaluated by comparing the performance of the system during a sunny day with that obtained during a cloudy day.

The Performance of the system powers during the sunny and cloudy days is indicated in Figs. 4(a) & (b), respectively. It is shown from Fig. 4 that the generated PV power is proportional to the variations in solar insolation only, while the battery power and the dumped power depend on the corresponding insolation level, the battery state of charge, and on the load demand. Also, it is illustrated from Fig. 4 that the load is satisfied with the required power, whatever the value of the corresponding insolation level.

Figures 5(a) & (b) indicate the state of charge of the system battery during the sunny and cloudy days, respectively. Thus, it is cleared from Fig. 5 that whatever the value of the insolation level be during the day, the maximum depth of discharge of the battery will not exceed the designed maximum permissible value which is 80 %.

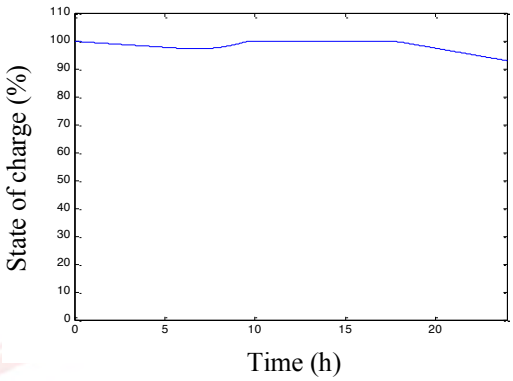
5. CONCLUSION

Remote and isolated areas usually need a stand-alone PV system to electrify their electrical loads. The configuration of the designed stand-alone PV system consists, mainly, of a PV array and a storage battery. The complete mathematical model of the designed system is developed and simulated by using MATLAB-SIMULINK. Also, the control of the system is optimally designed to issue the suitable control commands, which are based upon the current state of the system. Simulation results indicate that the overall performance of the system depends on the insolation level, state of charge of the battery, and on the load demand. The results indicate, also, the priority of the designed system to satisfy the load with the required power, whatever the value of the insolation level is. Moreover, they indicate the high capability of the designed control strategy in protecting the global stand-alone PV system against the hazards caused by the unexpected excess or deficit of the available energy. At the same time the results exhibit, also, the high capability of the control strategy in safely charging and discharging of the system battery.

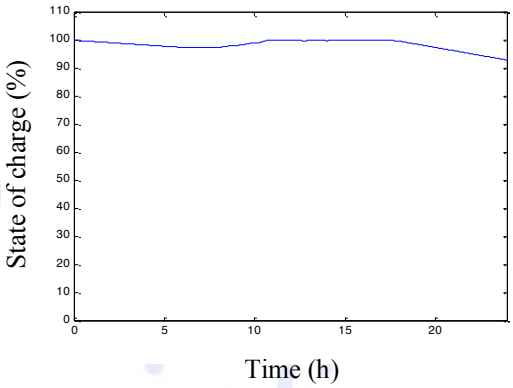


(a) During sunny day (b) During cloudy day

Fig. 4 Performance of the system powers.



(b) During cloudy day



(a) During sunny day

Fig. 5 State of charge of the system battery.

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Sustainable Management of Palm Oil Mill Waste Using Vermicomposting Technology

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Abstract:

Malaysia is the largest producer of palm oil (Elaeis guineensis). Collectively Malaysia and Indonesia contributes about 87 % of world palm oil production. Oil palm processing generates a large quantity of by-products including Palm oil mill effluent (POME) and palm press fiber (PPF). Palm oil mill effluent contains cellulosic material, fat, oil, and grease. Therefore discharging the untreated POME into the environment may result in harmful effect on human beings and also deteriorate the nearby environment. Decomposition of these by-products under natural conditions is a very difficult and time taking process. Vermicomposting technology could be an alternative and suitable method for the management of POME. The viability of vermireactors fed with POME and PPF was assessed over 45 day trials, under laboratory condition. Two different combinations in three replicates for each treatment as palm oil mill effluent: palm press fiber in 50:50 ratios (T1), palm oil mill effluent: palm press fiber: cow dung in 50:25:25 ratios (T2) were conducted. All the reactors performed sustainably with rising nutrients and worm biomass. The main objective of this work was to improve the efficiency of the reactors in terms of degradation of the wastes and higher production of the vermicompost. The attempt led to T2 vermireactor in which the number of earthworm increased as compared to T1 vermireactor. Moreover, experiment results showed improvement in nutrient characteristics of the vermicompost. Data showed that the major polluting problem in palm oil mills can be tackled through vermicomposting technique. The vermireactor with that is a combination of palm oil mill waste and cow dung performed sustainably, with earthworm's growth, and reproduction.

Introduction:

Several studies confirmed that vermicomposting is an alternative and cost effective solution to waste disposal problems [1]. During vermicomposting, essential nutrients, converted from the organic material, released [2]. Vermicomposting results in a useful material converted from organic waste by the action of earthworms and at the same time minimize pollution [3]. Vermicompost is a final peat-like material with excellent structure, porosity, drainage and moisture holding capacity [3, 4]. The nutrient content of vermicompost depends on the input materials. Usually, higher levels of most of the mineral elements included in vermicompost are available from the parent material [5]. Studies show that vermicompost promotes growth of plants by improving the physical, chemical and biological properties of the soil [6-8]. A wide range of organic wastes such as agriculture, urban and industrial waste [9, 10], textile mill sludge [11], leather mill solid wastes [12] and olive oil mill sludge [13], have shown to be suitable substrates for vermicomposting.

In Malaysia, oil palm is one of the rapidly expanding crops. The amount of waste generation increases by rising the demand of oil palm cultivation. According to [14] during processing, in the palm oil mill, more than 70% (by weight) of the processed fresh fruit bunch (FFB) are left over as oil palm waste. Yacob et al. [15] reported that 381 palm oil mills in Malaysia generated about 26.7 million tonnes of biomass and about 30 million tonnes of palm oil mill effluent (POME) in 2004.

The waste products from the oil palm processing consist of oil palm trunk (OPT), Oil palm frond (OPF), empty fruit bunches (EFB), oil palm mesocarp fiber (OPMF) and a vast amount of liquid discharged as palm oil mill effluent (POME) [16]. Palm oil mill effluent (POME) characterized by brownish colloidal suspension contains high concentrations of organic matter, high amounts of total solids (40,500 mg L^{-1}), oil and grease (4,000 mg L^{-1}), COD (50,000 mg L^{-1}), BOD (25,000 mg L^{-1}) and low pH ranging between 4 and 5 [16].

Discharging the effluent and by-products on the land results in environmental pollution and deteriorates the surrounding environment as well as contaminating the ground water. There is an urgent need for an efficient and different management system for the treatment of these by-products. POME contains 85-95% water, in order to obtain appropriate physical environment for the earthworms' growth, there is a need to integrate the POME with oligo-cellolusic materials.

There is no scientific study available on the efficiency of the earthworms in converting POME as an organic waste, into value added products. Therefore we have been conducting investigations aimed at feasibility of vermicomposting of POME [17]. In this work the continuity of vermicomposting has been carried out to enhance the process by using cow dung as a source of organic nutrients.

Experimental Outline

Two different treatment groups with three replicates each were setup as POME: PPF in 50:50 ratio (T1) and POME: PPF: CD in 50:25:25 ratios (T2). The vermicomposting reactor (34cm x 36cm x 11cm) was set up for 45 days in laboratory condition. Small holes were drilled at the bottom of each unit to drain away excess water. 20 clitellate earthworms of Lumbricus rubellus

having average live weight of 3.92 g were introduced to each setup containing 2000 g (on wet weight basis) of substrate after 120 hours of pre-composting. Moisture was maintained throughout the study by sprinkling of adequate quantity of tap water. In order to prevent moisture loss, vermireactor were covered with jute bags. Chemical parameters were analyzed in all treatments before the introduction of earthworms and after every 15 days, up to 45 days. The worms were separated from the reactors by hand sorting, counted and weighted weekly to obtain the earthworm biomass throughout the experiment. Data obtained was subjected to One Way ANOVA by using PSAW statistics 18 and all values presented as the mean ± SD (standard deviation). The probability levels used for statistical significance were $P < 0.05$.

Result and Discussion

We have presented our findings in which the feasibility of vermicomposting of POME has been done by using PPF as oligo-cellolusic material to absorb the excess moisture of POME and results in providing beneficial material such as N and K [17]. We now present findings of the experiment in which apart from the efficiency of vermicomposting of POME, one more step was taken by us which significantly enhanced the vermicomposting of POME with almost nil addition cost.

The pH value of the two treatments are presented in Figure2. Initial data indicates the time of adding the earthworms (after120 hours of set up time). Addition of acidic POME into PPF makes facilitates the mixture to come up with the pH that is suitable for growth and survival of earthworms. pH of the both treatments ranges between 7 and 8 throughout the experiment which the best range for activity of earthworms. Similarly EC increased in both treatments (Figure2) which is due to the loss of organic matter in the mixture substrate[18].

Figure 1: pH value of different treatment during v

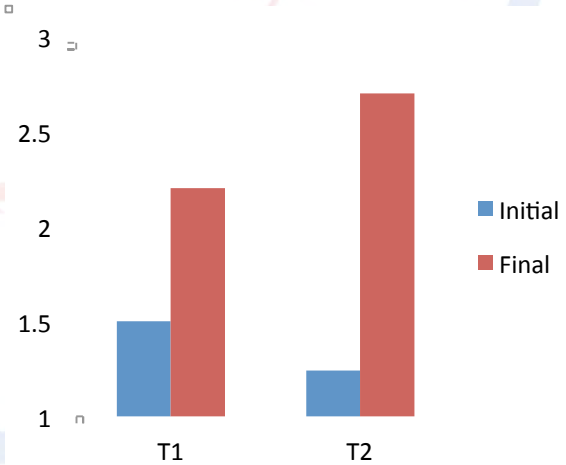

Figure 2: EC value of different treatment during vermicomposting

The loss of organic carbon dioxide in the process of respiration and production of mucus by earthworms leads in reduction of C: N ratio in the substrate. CN ratio indicates the degree of decomposition during the process. Table1 illustrates that OC decreases in the both treatments whereas nitrogen increased. This causes in reduction of C: N ratio in both treatments. Satisha and Devarajan [19] reported that CN ratio below 20 is considered as acceptable maturity of the

compost. Results show that CN ratio in treatment 2 in which cow dung was added has more reduction as compare to the treatment 1. Therefore it can be conclude that addition of cow dung makes the compost into the satisfactory degree of organic waste.

Parameters	[a]T_1		[b]T_2	
	Initial	**Final**	**Initial**	**Final**
N (%)	0.78	2.31	1.1	2.53
OC(%)	44.30	39.01	44.39	33.52
CN	58.68	17.13	40.30	13.23

[a]Palm oil mill effluent:palm press fiber (50:50)
[b]Palm oil mill effluent:palm press fiber:cow dung (50:25:25)

Table1. C: N ratio in different treatments through vermicomposting process

L.rubellus used in this study has the ability to live in decaying organic waste and produce nitrogen rich products. Figure 3 shows the growth of earthworms in the both treatments which were significant throughout the study.

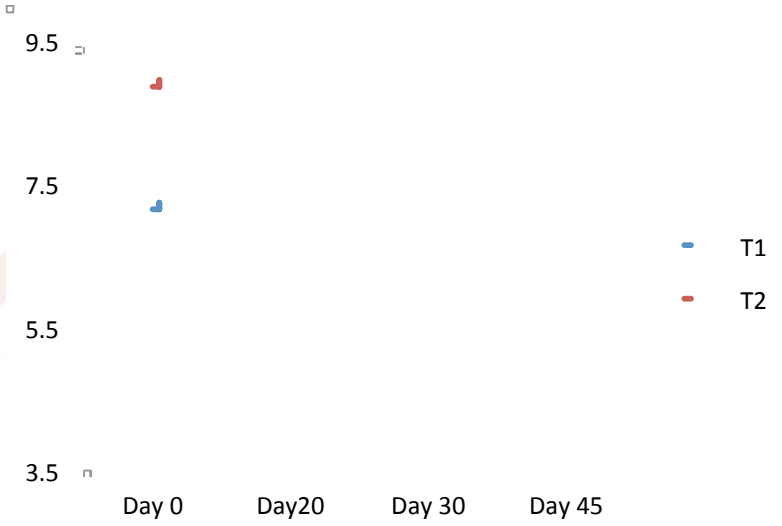

Figure 3: Growth of *L.rubellus* in different treatments throughout the experiment

Both treatments show significant growth of earthworms through vermicomposting process. Treatment 2 shows highest growth of earthworm which is due to the addition of cow dung as a nutrient rich organic waste. Results shows that cow dung facilitate and accelerates the earthworm growth and reproduction. Accumulation of the excretion of the earthworms which might be toxic for them caused a reduction in growth and reproduction by the end of the experiments. Therefore earthworms can digest the palm oil mill effluent mixed with palm press fiber and reach to their maximum growth by 30th day of process. Moreover addition of cow dung results in a better growth of *L. rubellus*.

Conclusion

The study positively shows that acidic palm oil mill effluent (pH 3) can be decomposed through vermicomposting process by addition of palm press fiber (pH 5.9) and other inputs to neutralize the pH to 8. Cow dung play a significant role in stabilizing the mixture, C: N 14.81± 0.07 in T2, accelerates the vermicomposting process. This results in increasing the earthworm growth, reducing the time taken and produces a good quality of vermicompost as end product.

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Responsiveness and the Resilience of Queensland Economy to Climatic Disasters: Through a Post-Keynesian Lens

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Abstract:

Natural disasters and their economic impacts have been neglected in the main stream of development and growth theories. Only recently a body of research into the economic effects of natural disasters began to emerge. This body of literature considers both the socio-economic impact caused by natural disasters and how the socio-economic conditions within a country prior to a natural disaster impacts on the response to disaster event when it occurs. However, most of these discussions fail to adequately integrate this relationship into a general macro-economic model. This paper attempts to analyse the dynamic effect of climatic disasters on key economic variables of the state of Queensland for the period of 1980 to 2008. A Kaleckian-Post-Keynesian multi-sectoral open economy model, which is augmented by a demand driven labour market, a reserve army effect in the Marxian sense and technological change is being utilised and econometric long run relationship between variables are investigated.

The paper predominantly emphasises on the link between climatic disasters and sources of economic growth such as state accumulation, savings, income distribution and labour market fluctuations. By employing the Structural vector autoregressive (SVAR) approach by imposing short and long-run restriction on SVAR model. The short run restrictions impose contemporaneous feedback effects among the real sector economic variables and indicators of natural disasters following the methodology described in Bernanke (1986), Blanchard and Watson (1986), and Sims (1986), and the long run restrictions in SVAR approach is an alternative to cointegration for capturing long-run equilibrium relationships.

In this study we assume that Queensland economy faces exogenous, random shocks (unexpected variation) to climate conditions, which can have substantial impact on key economic indicators, then the main intention is to examine whether key economic indicators differ significantly in their responses to climatic shocks in the medium term to long run.

1. Introduction

United Nation International Strategy for Disaster Reduction Secretariat (UNISDR 2008) defines disasters as "A serious of the functioning of a community or a society causing widespread human, material, economic, or environmental losses which exceed the ability of the affected community or society to cope using its own resources". Natural disasters can also be reviewed as a risk integral to development instead of interruptions (ADB, 2009) and this vulnerability can be reduced by controlling disaster risk through making disaster risk management a vital consideration in policy-making process (Freeman, Martin et al. 2003). In recent studies the importance of economics of the climate change, natural disasters shocks and responses to the have been highlighted, however, most of these discussions fail to adequately integrate this relationship into a general macroeconomic model.

The agriculture and coal and mining industries in Queensland have been hardly hit by the occurrence of recent natural disasters in the region. 80% sorghum crop has been damaged and coal exports was about 15 million tonnes lower than expected from December 2010 to March 2011 (The Courier Mail, 2011)[1]. Financial market made quick responses to crises as reflected by the movements on prices of particular stocks such as QLD based mining companies. Volatility has also been witnessed in capital market through movements on market index in general, which the damage on agriculture and mining industries both contributes to it. The occurrence of recent QLD natural disasters limits the option of agriculture products on the market and the output of resource products, which force the commodity price rising dramatically. As the consequence, energy and agriculture sectors of commodity future market experienced dynamic market movements as well. Therefore, we also aim to show the impact of recent QLD disasters on Australian stock and capital market and explore the significance of this impact.

Therefore, the main objective of this paper is to analyse the dynamic effect of recent years natural disasters on Queensland's key macroeconomic indicators, and to investigate the degree of responsiveness of different sectors of the Queensland economy to region's recent natural disasters by modelling and studying economic impacts these shocks using the contemporaneous feedback effect analysis. The research also focuses on the trade-off between natural disasters and sources of economic development of the region such as investment, saving, income distribution and labour market fluctuations. In this study we assume that Queensland economy faces exogenous, random shocks (unexpected variation) to climate conditions, which can have substantial impact on key economic indicators, then the main intention is to examine whether key economic indicators differ significantly in their responses to climatic shocks in the medium term to long run.

2. Literature Review

A body of research into the economic effects of natural disasters has been emerging since the 1980s, considering both the socio-economic impact caused by natural disasters and considering how the socio-economic conditions within a country prior to a natural disaster impacts on the response to the natural disaster when it occurs. There have been two distinctly different approaches to research in this area, considering either impact of disasters across a

[1] http://www.couriermail.com.au/business/agriculture-and-mining-hit-hard-by-loss-of-production-due-to-floods-in-eastern-australia/story-fn7kjcme-1225992475038

range of countries to assess how the disaster impact is mitigated or increased by local factors, or considering the impact of a specific disaster or disasters over time in one specific region or country to see how local economic conditions are affected by the disaster.

Within the first category of research, a large number of authors have conducted research focussing on a wide range of countries. They have compared the different economic impacts resulting from a wide range of natural disasters affecting these countries, and drawn conclusions on how the existence of differing socio-economic factors before the natural disasters affect the impact the natural disaster has on the economy. This has also resulted in a range of policy recommendations to enable a country to be better prepared for any natural disaster that may befall it. Several authors (Gassebner, Keck et al. 2010), (Ibarrarán, Ruth et al. 2009), (Noy 2008), (Padli, Habibullah et al. 2010), (Toya and Skidmore 2006) found that developing countries experience much larger shocks to their macro-economies than developed countries. Additionally these researchers found that countries with larger economies, higher literacy or educational attainment, better institutions, higher incomes per capita, larger government structures, higher degrees of openness and democratic rather than autocratic governments appeared better able to prevent disasters adversely affecting macro-economic factors.

In further work exploring the reasons for these findings, Skidmore and Toya (2002) established that disasters provide opportunities to update capital stock and adopt new technologies which increases factor productivity and induces higher GDP growth. The positive factors identified above all contribute to the country's ability to take advantage of this opportunity in a way that a poor and underdeveloped country could not.

Hallegatte and Ghil (2008) extended this analysis to consider differences in economic impact depending on whether the natural disaster occurred during a time of economic boom or recession, finding that a disaster occurring during a recession would have a far more favourable impact on the economy, due to the availability of human and physical capital for the rebuilding work required, compared to a disaster during a boom where shortages of capital can delay rebuilding efforts and cause inflation.

Other studies such as Kahn (2005) have considered the relationship between the level of GDP and the number of deaths from natural disasters, finding that although the incidence of natural disasters was no different in richer and poorer countries, the number of resulting deaths from such disasters was significantly higher in the poorer countries.

In the alternate approach to research in this area, a number of authors have focused on a specific natural disaster or series of natural disasters in a particular region and examined the impact of disaster(s) on the economy, and then attempted to draw conclusions from that specific disaster impact that can be applied to a wider range of scenarios. The most commonly studied region and type of disaster has been the impact of hurricanes in the USA. Hurricanes cause a wide range of damage through wind, storms and flooding, and occur fairly frequently, for example there were 19 significant hurricanes in Florida alone between 1988 and 2005 (Belasen and Polachek 2008) and therefore provide a good source of varying data and scenarios suitable for study.

Belasen and Polacheck's (2008) study on the impact of hurricanes on Florida found that the disasters caused significant increases in earnings but decreases in employment levels in the directly affected regions, whilst causing reduced earnings in neighbouring regions, with the effects dissipating over time. Veen and Logtmeijer (2005) also found that disasters could

have an economic impact on regions outside the affected region if the outside areas economic infrastructure passed through the disaster zone.

Shaughnessy et al (2010) found that hurricanes had an immediate and sustained effect of reducing the inequality of incomes whereas Chang (1983) found that the initial impact of the disaster was positive, significantly increasing revenues, but over time the full effect became negative. Xiao (Xiao 2011) also found a short term impact of reduced employment but also found a decrease in per capita income initially, but this rebounded over the next few years assisted by insurance and government support the rebuilding effort, other than in the farm sector where the decline in employment and income was long term and significant. Burrus et at (2002) also found a rebound in activity due to rebuilding efforts mainly funded by insurance and government assistance for high intensity hurricanes, but found that low intensity hurricanes cause a significant impact on economic activity as there is no rebound effect and these type of hurricanes occur with far higher frequency than the major hurricanes. In another study which included considering the intensity of the hurricane, Hallegatte (2008) found that above $50billion the total losses caused by the disaster increased in a non-linear relationship with the direct losses caused, indicating that for major disasters the direct loss was not a good indicator of the economic damage caused by the disaster.

Outside of research on the USA, in a study focusing on Australian natural disasters, (Worthington and Valadkhani 2004) it was found that certain natural disasters, namely cyclones, bushfires and earthquakes, did have a significant impact on the Australian stock market, however no significant effect was found from floods and storms. This study did not attempt to consider wider economic impacts of these disasters on Australia. Albala–Bertrand (1993) studied disasters in Central America and found that falls in output due to disasters were a very small portion of the total countries GDP and compensation required to rebuild was an even smaller portion, therefore natural disasters do not have a significant impact on the total economy of the country effected. (Charveriat 2000) argues that in the short term, major natural disasters might have an impact on a country's GDP due to the loss of assets and the associated disruption of economic activity. But GDP growth and other flow indicators do not fully capture the effect of disasters, whose principal impact is on the stock of human and physical capital. In the longer term, the destruction of capital can have effects on factor endowments, income distribution, regional inequalities, growth trajectory and public indebtedness.

Different researchers have used a range of different modelling approaches, including input-output models (Burrus, Dumas et al. 2002), (Hallegatte 2008), (Veen and Logtmeijer 2005); autoregressive integrated moving average regression models (Baumann, Baade et al. 2007), (Xiao 2011), (Worthington and Valadkhani 2004); income density functions (Shaughnessy, White et al. 2010); and other regression analysis based approaches (Belasen and Polachek 2008), (Schmidt, Kemfert et al. 2010). However, West and Lenze (1994) cast doubt on the reliability of regional models for predicting the effects of natural disasters due to the complex linkages and problems in obtaining sufficient accurate data.

Whilst a number of the cross country comparison papers referred to above included Australia within their sample, there has been little research specific to Australia other than Worthington and Valadkhani (2004) who focused purely on the impact of natural disasters on the stock market. This paper seeks to address the gap in the literature by employing a Kaleckian-Post-Keynesian open economy model to model scenarios demonstrating how Queensland's recent natural disasters have affected the key macroeconomic indicators, and examine the different

responses of the different indicators to the exogenous severe weather shocks in the medium to long term.

3. Methodology

3.1 Empirical Model

We utilise a Kaleckian-Post-Keynesian open economy model, which is augmented by a demand driven labour market, a reserve army effect in the Marxian sense and technological change. This model was first introduced by (Bhaduri and Marglin 1990) and later extended by Stockhammer and Onaran (2003 and 2005). The goods market consists of behavioural functions for accumulation, savings, and net exports, and is then complemented by a distribution function, a productivity function and unemployment. In this study we assume that economy faces exogenous, random climate shocks, which can have substantial impact on key macroeconomic indicators, then the main intention is to examine whether key macroeconomic indicators differ significantly in their responses to severe whether shocks (unexpected variation) in the medium term to long run (see Chaiechi 2012).

By employing the Structural vector autoregressive (SVAR) approach, the study firstly investigates that if there is a cointegrating relationship between the key variables and whether proxies by imposing short and long-run restriction on SVAR model. The traditional means of analysing an estimated structural VAR model is through the impulse response function (Hamilton, 1994). Impulse response functions represent the dynamic response of a variable in the model to an error term (referred to as a shock or innovation) in one of the structural equations. The short run restrictions impose contemporaneous feedback effects among the real sector variables and whether/ climate shocks following the methodology described in Bernanke (1986), Blanchard and Watson (1986), and Sims (1986), and the long run restrictions in SVAR approach is an alternative to cointegration for capturing long-run equilibrium relationships.

The outcome of post-Keynesian assumption is that more investment and accelerated endogenous technological change leads to higher employment rate and increases the export volumes and consequently achieves higher economic growth. Post Keynesian models also accept the possibility of repeated market failures and externalities, and acknowledge the importance of structural changes, therefore post Keynesian prefer multi-sectoral models over aggregated models. Another important implication that PK models have is that they argue policies to increase accumulation will lead to higher economic growth and technological changes, however not all technological changes increases the rate of economic growth Consequently these models seem to be especially suitable for sustainability analysis.

Accumulation $$g_t^i \equiv \frac{I_t}{K_t} = \alpha_0 + \alpha_1 z_{t-1} + \alpha_2 \pi_{t-1} - \alpha_3 r_t + \alpha_4 gx_{t-1} + \alpha_5 dv_t + \alpha_6 Dis_t \quad (1)$$

Savings $$g_t^s = \beta_1 z_t + \beta_2 \pi_t + \beta_3 Dis_t \quad (2)$$

Income Distribution $$\pi_t = \gamma_0 + \gamma_1 z_t + \gamma_2 u_t + \gamma_3 gx_t + \gamma_4 Dis_t \quad (3)$$

Productivity growth $$gx_t = \tau_0 + \tau_1 g_t^i + \tau_2 z_t + \tau_3 Dis_t \quad (4)$$

Net Export $$nx_t = -\delta_1 z_t + \delta_2 \pi_t + \delta_3 Dis_t \quad (5)$$

Employment $$u_t = n - e_1 g_t^i - e_2 \Delta z_t - e_3 \pi_t + e_4 u_{t-1} + e_5 gx_t + e_5 Dis_t \quad (6)$$

Market equilibrium $$g_t^i = g_t^{stotal} = g_t^s - nx \quad (7)$$

g_t^i *: Growth of Capital Stock (investment)* g_t^s*: Saving Rate*

z *: Capacity Utilisation (capital productivity)* π *: Profit share*

r *: Interest rate* nx*: Net export (normalised by GDP)*

u *: Unemployment rate* gx *: Productivity Growth*

Dis: Dummy variable for Disasters

3.2 Data and Variables Definition

The variables we have included in the model are the variables from the system of equations, including investment, savings, income distribution, unemployment, productivity growth , and net export as endogenous variables, and interest rate, capacity utilisation, and natural disaster dummy variable as exogenous variable. The followings provide ways in which variables are proxied, collected and measured. The data were obtained from various sources such as Australia Bureau of Statistics (ABS), Reserve Bank of Australia (RBA), the Office of Economic and Statistic Research - QLD government, and the Bureau of Meteorology for the period of 2002: Q1 to 2010: Q4 for the state of Queensland.

Data on number of disasters experienced is considered as a measure of inherent vulnerability in the absence of mitigation; however one should note that this measure does not accurately portray current vulnerability to natural disasters. Natural disaster variable enters into our model as a dummy independent variable. Since the unit of observation is time in this research, the dummy variable represents whether, in each time period (quarterly in this case), natural disasters (Flood and Tropical Cyclones) have occurred in QLD during 2002: Q1 to 2010: Q4. Therefore, dummy variables used in this paper tend to isolate certain quarters that are systematically different from other periods covered by the dataset, in a way that periods with no disaster are given 0 as value for the dummy variable and quarters in which natural disaster are experienced are given 1. Natural disasters in this study refers to the number of time Queensland has experienced major Floods and Tropical Cyclone events , other types of natural disasters such as Bushfire, Earthquakes, Tsunamis are not taken into consideration as the state is not prune to such disasters.

Investment: The estimates of capital stock and consumption of fixed capital are prepared using the perpetual inventory method (PIM). The accumulation (investment) is measured using the following:

Investment= Physical capital stock + (1- depreciation rate of capital) x Grossed Fixed Capital Formation

Income distribution or Profit Share: following (Dutt 1995) rate of profit can be expressed as; $r = (1-Va)\ u$, where V is the real wage rate, a is the ratio of labour to GDP and therefore income distribution or profit share in income will be $(1-Va)$.

Capacity Utilisation: the actual capacity utilisation (u) can be expressed as $u=Y/K$, where K is stock of physical capital and Y is nominal GDP.

Savings : saving is the ration of Gross savings/ GDP.

Productivity Growth : growth rate of K/L, where L is the number of labour and K is capital.

Net Export : difference between export and import normalised by GDP.

Unemployment Rate: data on unemployment rate are available for the state and is understood as percentage per annum.

Interest rate: Interest rate is measured applying the following formula. IRT= (DEP+1)/ (INF +1), where DEP is deposit rate and INF is inflation rate

Natural Disasters: The number of natural disaster events historically experienced in Queensland during 1980-2010.

4. Estimation Techniques

4.1 Stationarity

Many economic time series exhibit trending behaviour or non-stationarity in the mean, and may have no tendency to return to a long-run deterministic path, therefore a linear combinations of non-stationary time series will lead to spurious regression. Moreover, for a Structural VAR approach, advanced by (Shapiro and Watson 1988) and (Blanchard 1989) showed that if variables are non-stationary, shocks continue to accumulate over time and so have permanent effects. Therefore, the presence of unit roots in the variables can give rise to spurious regression if the VAR is estimated in levels.

We follow (Granger 1986) that states a non-stationary time series can achieve stationarity if the series is differenced appropriately. A series is integrated of order d, I(d), if the series becomes stationary after differencing d times. So we determine whether the variables to be included are $I(0)$ or $I(1)$. This will determine whether a reduced form representation in levels or in first differences is required. For this purpose, the augmented Dickey-Fuller (ADF) unit root test has been conducted and results are provided in Table 1.

Table 1: Stationarity Tests

	Augmented Dickey-Fuller			
	Level		**First D**	
	No Trend	**Trend**	**No Trend**	**Trend**
Investment	0.1913	0.9999	0.0236*	0.0084***
Savings	0.1452	0.2668	0.0000***	0.0001***

Income Distribution	0.0663 **	0.2102	0.000***	0.000***
Productivity Growth	0.0005***	0.000***	0.000***	0.000***
Net Export	0.3752	0.3507	0.0004***	0.0024***
Unemployment	0.1689	0.9328	0.000***	0.000***
Capaity Utilisation	0.1517	1.0000	0.0504**	0.0116*
Interest rate	0.1641	0.3511	0.0032***	0.0166**
Disasters	0.000***	0.000***	0.000***	0.000***
Profit rate	0.1518	0.9999	0.0504**	0.0116*

*** (**), (*) indicates that t-statistic is significant at 1% (5%), and (10%)

One major issues in performing ADF tests are the inclusion (or not) of an intercept term, a trend term, or both. ADF test results are very responsive to the presence of intercept and trend terms, so the ADF test is carried out both with "intercept (no trend)" and "intercept with trend" and the probability of t -statistics are provided in the table above. The result of ADF test indicates that is almost impossible to reject the null hypothesis of a unit root (non-stationary data) for all the variables at level. However, by differencing the data once and reapplying the test, it seems that stationary data are achieved and the null hypothesis of unit root is easily rejected mostly at 1% significance level. The results show that the variables are integrated at first difference (i.e. the data are I(1)), and the conclusion is that from now on the first differences of the variable series are used in the analysis, which display a stochastic trend.

4.2 SVAR Identification and Estimation

VAR methodology does not consider the structural relationships among the variables. In this sense, Structural VAR (SVAR) analysis attempts to solve the traditional identification problem. SVAR framework allows investigating what exactly a given theoretical view implies for the dynamic linkages in an empirical model which has been identified on this basis (Gali 1992). SVAR models allow for the estimation of structural shocks and impulse responses (dynamic linkages) from empirical data and therefore, can be used to evaluate economic theory. SVAR models therefore require additional information about the theoretical setup in order to identify the structural parameters; this identification is obtained by imposing parameter restrictions that can be justified by the economic theory. Therefore, the SVAR can be used to predict the effects of specific policy actions or of important changes in the economy (Narayan, Narayan et al. 2008). We follow (Stockhammer and Onaran 2003) and (Stockhammer 2005) that explicitly explains the post- Keynesian restrictions imposed on the VAR model to investigate contemporaneous feedback effects among variables. The SVAR model in this paper unambiguously favours Post-Keynesian macroeconomic theory and gives priority to the hypothesis that investment causes Savings (for more details see (Chaiechi 2012)). Therefore, the ordering of the variables according to the Kaleckian Post-Keynesian theory which we used throughout this study is the vector:

$$Y_t' = (INV_t, SAV_t, AW_t, NX_t, GX_t, U_t)$$

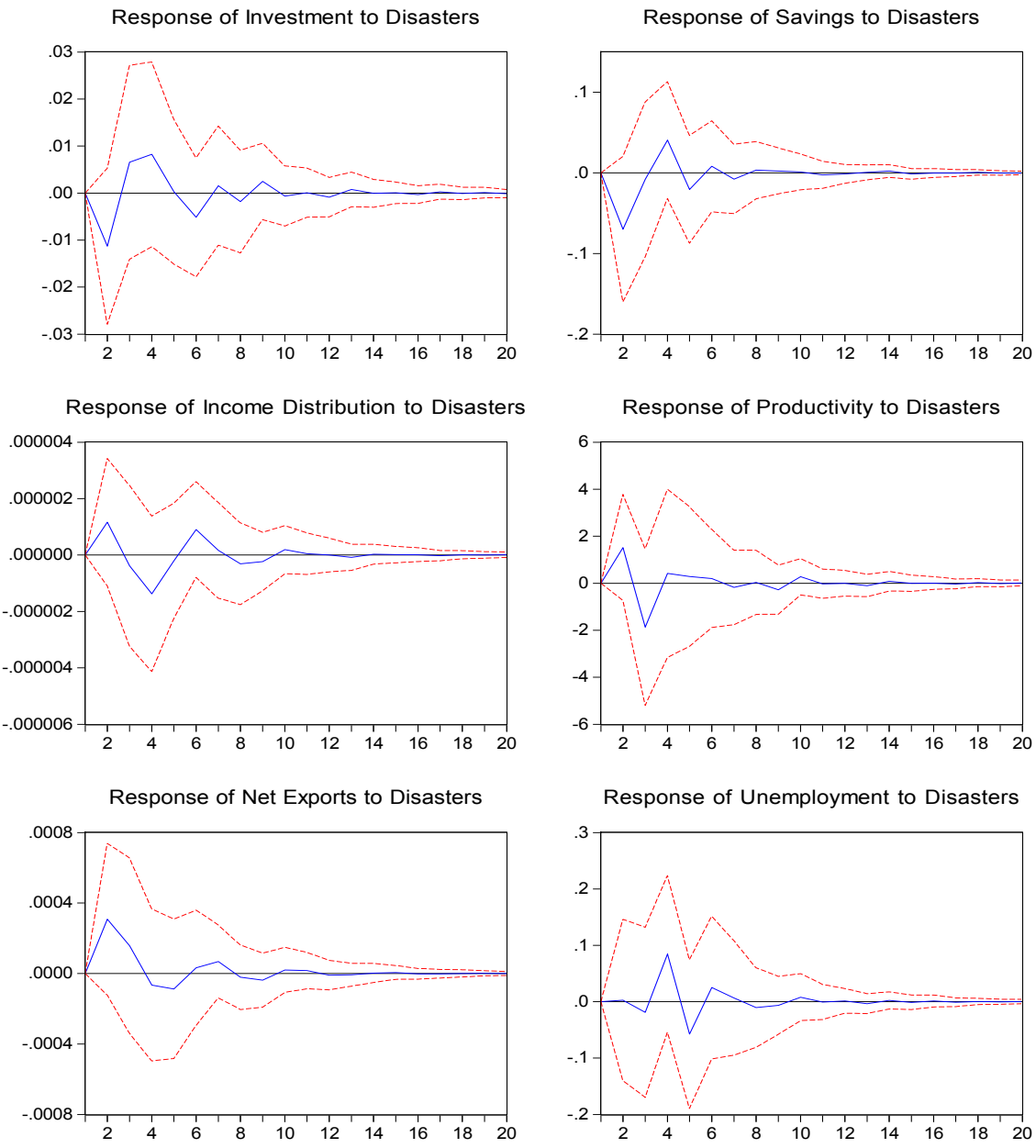
The results of SVAR modelling is not provided here due to space strength, however, the results indicate that a higher level of investment significantly boosts the volume of export , which is in line with our Kaleckian macroeconomic model indicating investment as the drive for economic growth.

4.3 Impulse Response Function (IRF)

Impulse response functions represent the dynamic response of a variable in the model to an error term (referred to as a shock or innovation) in the structural equations. The transmission of the shock will depend on the form of the structural equations. Plotting the impulse response function is a practical way to visually represent the behaviour of variables in our model in response to the natural disasters shocks. These shocks are unexpected variations in climatic event and can have substantial impact on key macroeconomic indicators, particularly on investment, productivity, export and consequently on labour market outcomes. Figure 2 show the impulse response functions. The standard error bands are obtained by Monte Carlo standard errors. Graph includes a point estimation of impulse response functions as well as lower and upper bounds for a 95% confidence interval. The solid blue line portrays the macroeconomic variables changes in response to a standard deviation of one whereas the dotted lines represent the 95% error bands. The speed of adjustment after a structural shock (disaster shocks) is measured by the number of periods before the impulse-response functions cross the zero line. The sizes of the shocks applied to the SVAR system in this study are measured as one-standard deviation shock of the structural error.

Figure 2 represents the responses of the key macroeconomic variables to the occurrences of natural disasters (Flood and Cyclones) in Queensland economy. Unexpected change in climatic events seems to create immediate and sharp decline in investment and savings levels which last around a year (4 quarters) before it goes back to the pre-shock level (ceteris-paribus), this in the short run is due to the destruction of physical capital and infrastructure including factories, property, equipment, roads, and other assets. The impact on national savings will be negative simultaneously as more resources are now required to be allocated to capital accumulation post-natural disasters. The response of Productivity is initially positive for couple of quarters and then negative for another couple of quarters before it becomes slightly and steadily positive for a long term before it crosses the zero line and meets the pre-disaster level. The World Bank found that floods, while negatively impacting agricultural production in the short-run through crop damage, can increase productivity in the long-term as a result of improved soil fertility (The World bank 2011). The reason that the productivity can be affected positively by disasters in the long run can be justified by the fact that when disasters strike tendency for adapting new technologies that further improve the long term economic productivity will increase , these new technologies are often more resilient to the severe climatic events (Hallegatte & Dumas, 2009; Skidmore & Toya, 2002).

Figure 2: Impulse response of the Key macroeconomic indicators to the climatic shock (i,e Natural Disasters)



Loss of capital and investment and reduction in income distribution (producer's profitability) after the second quarter will place upward pressure on prices and wages which consequently will increase unemployment, this is the effect that starts showing almost 3 quarters post-disaster.

5. Conclusion

In particular, the magnitude and volatility of the responses to disaster shocks was studied, and results consistently indicate that disaster shocks have significant and rather long-lived (up to 10 quarters after events) persistent impact on major macroeconomic indicators, however, all six macro indicators (investment, Savings, Income distribution, Productivity, net export and Unemployment) show stability signs and that they are able to absorb the disaster shocks with

some delays (up to 10 quarters in average). Result conclude that, while the economic impact of the Queensland's recent natural disasters have been significant and while recent flood ad cyclone events have altered the profile of economic activity and growth of the state , it is likely that the impact of disasters lessen in medium run and the shocks are fully absorbed by economic units of the state. This can be due generation of huge amount of economic activities which results from reconstruction programs that are mainly funded by Federal Government (partially through one-off levy and spending cuts). These economic activities target rebuilding homes, restoring workplaces and fixing up damaged infrastructure.

The impulse response analysis shows an obvious possibility that macroeconomic and employment shocks by natural disasters truly do not affect the economic stability of the state in long term and the effects of such shocks are rather temporary and a turnaround in different sectors of state economy is expected within 2 years after occurrence of disaster events. The final conclusion is that natural disasters (Flood and Tropical Cyclones) will alter economic profile and economic growth of Queensland overtime, however, the impact of disaster events on key economic indicators is expected to smooth out in the medium term.

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A Model of Health Impact Assessment for the Sub-District Municipalities:A Case Study of the Songkhla Lake Basin.

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Abstract:

Background: In Thailand Health impact assessment (HIA) has currently legislated two laws: the Constitution of the Kingdom of Thailand B.E 2550 (2007) and the National Health Act B.E. 2550 (2007). Both laws are important for local authority to use the HIA as a tool for building sustainable community.
Objective: The objective of this study was to develop a health impact assessment model for the sub-district municipalities in the Songkhla Lake Basin,Thailand.
Methods: This research and development consists of 4 phases, as follows.The first phase was pre specified model development, where the objective was to explore the HIA model. The second phase was the specified model development, and the third phase was model development, the objective were to improve and modify the model of the HIA by specialists. The last phase was public review, and here the objective was to propose and improve the appropriate model for the sub-district municipality. The study areas were comprised of 23 sub-district municipalities in the Songkhla Lake Basin. The study data were collected using participatory observation, in-depth interview, and focus group discussion, all of which were finally analyzed using the content analysis method.
Results: The results of the first phase revealed that a possible model for the HIA for the sub-district municipality in Songkhla Lake Basin was as follows. The first model was the model of the HIA for integrating the HIA process regarding policy or project development. The second model was the model of the HIA for the sub-district municipality, where there were significant health impacts,community conflicts or there were uncertain health impacts from project implementation. The third model was the community health impact assessment model.
Conclusions: The results of this study will benefit the sub-district municipality in terms of applying or conducting the HIA for the benefit of public health policy and the public's well being.

1.Introduction

In Thailand, The National Health Act B.E.2550 Section 3 defines health as "*the state of a human being which is perfect in physical, mental, spiritual and social aspects, all of which are holistic in balance."* [2] Health is affected by the social determinants of health, and the social determinants of health are factors which influence health status or determine health differential. There are 3 mains factors in the social determinants of health: environment, personal, and the system or mechanism. Improvements in the health of the population cannot be achieved by health services alone. Health is influenced by the activities in many other sectors.[1] The policies, programmes, and projects in many sectors affect health. Health Impact Assessment (HIA) is a tool that can predict health impacts in order to recommend or improve policies, programmes, and projects to improve health. The benefits of HIA are for example predicting and assessing the potential of the health impact of projects, plans, and policies. HIA is based on a holistic approach to well-being and is used to reduce inequalities in health. It can also be used as a way of highlighting the effects that the wider determinants of health have on people's well-being [1].

HIA has been defined as *"a combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population"* [2][3][4][5][6].

For Thailand, The National Health Commission Office has been defined as *"a joint learning process of society to analyze and anticipate both positive and negative impacts on the health of the people that may result from one of, or a combination of, policies, programs or projects when implemented at the same time, or in the same area, by applying various tools and appropriate participatory processes in order to support the decision making that will benefit the health of the people, in both the short and the long ter"*[7].

The Thai Constitution 2007, Section 67 Paragraph 2, states that *"...any project or activity which may seriously affect the quality of the environment, natural resources or health shall not be permitted, unless its impacts on the quality of the environment and on the health of the people in affected communities have been studied and evaluated, and consultation with the public and interested parties has been organized"* [9].

Local decision-makers must think about the effect which their policies may have on health, and in particular how they can reduce negative health impacts and health inequality or maximize positive health impacts.

The general process of HIA comprises five main stages [2].

1. Screening: It is not possible to carry out an HIA on every project, policy, or programme. Therefore screening is used to systematically decide when to do an HIA.
2. Scoping: Scoping sets the boundaries for HIA, and considers how the HIA appraisal stage should be undertaken.
3. Appraisal: Identifying health hazards and considering the evidence of impacts.
4. Reporting: Developing recommendations to reduce hazards and/or improve of health.
5 Monitoring: Evaluating whether the HIA has influenced the decision-making process (and the subsequent proposal) is an important component of HIA.

The values of HIA are those of democracy, equity, community participation, and sustainable development[2]. HIA is widely applied word-wide. There are various HIA models, both in Thailand and in other countries. If an institute wants to conduct an HIA, what is the appropriate model to be used? In each model there are different forms, processes, tools, and methods for identification of health impact and HIA focus. The objective of this study was to develop an HIA model for local authorities, especially the sub-district municipality in Songkhla Lake Basin.

2 METHOD

This research consists of 4 phases; however, in this paper focus will be placed on the 1st and the early part of the 2nd phase as follows:

The first phase was prespecified model development, where the objective was to explore the HIA model published world-wide. A systematic literature search was conducted using search engines such as Google, splinker link, science direct, PubMed, and others. The data analysis was content analysis. The output of the first phase was the First Model .

The second phase was the specified model development, and the objective was to study the enabling factors and barriers which influenced conducting HIA in the sub-district municipalities. The data collection used the survey and in depth interview method. One-to-one interviews were conducted with 23 key informants. The questions covered the following topics areas:

- Organization factors (staft, knowledge, time);
- Organization support for HIA (human, funding, tool, HIA knowledge);
- Partnerships;
- HIA experience/skill;
- Type of support needed for current HIA and future work in the sub-district municipality (training needed, tools, knowledge);
- The scenario in the sub-district municipality and the level of the community participation.

The third phase was model development, aiming to improve and modify the model of the HIA by specialists. The fourth phase was public review, and here the objective was to propose and improve the appropriate model for the sub-district municipality. The study areas were comprised of 23 sub-district municipalities in the Songkhla Lake Basin. The study data were collected using participatory observation, in-depth interview, and small group discussion, all of which were finally analyzed using the content analysis method.

3 RESULTS

The results of this paper will focus only on the results of the 1st phase and the early part of the 2nd phase.

3.1 The results of the first phase, documentary research, revealed that a model of health impact assessment for the sub-district municipalities may be conducted by using the 3 models. The possible model of health impact assessment in the sub-district municipality is as follows:

The first model was the HIA model as an integral part of planning. It should be a prospective model, conducted before the implementation of a policy proposal. The process of this model consists of 7 stages: set a steering committee, screening, public scoping, appraisal, public review, recommendations and decision making, and monitoring and evaluation, as exhibited in figure 1.

The second model was the model that was conducted to predict or to assess the impact of concurrent plans, projects, and activities in order to minimize negative health impacts and to maximize positive health impacts. The type of this model may be a concurrent or retrospective HIA. The process consists of 6 stages: screening, public scoping, appraisal, public review, implementation, and monitoring and evaluation, as exhibited in figure 2.

The third model was the community health impact assessment model (CHIA). Community health impact assessment is a way to bring the health concern of the community forwards in the discussion of public policy. CHIA allows communities to:

- Estimate the effect that a particular activity (a policy, program, project, or service) will have on the health and the well being of the community.
- Identify things to do that will maximize the benefits (the positive effects) and minimize the harm (the negative effects) of that activity. The process of the CHIA consists of 7 stages, as shown in figure 3.

Step 1 Answer the question "What does it take to make and keep our community healthy?"
Step 2 Develop a version of a Healthy Community.
Step 3 Design the community health impact assessment tool (CHIAT)
Step 4 Test the tool.
Step 5 Make a plan to use the CHIAT.

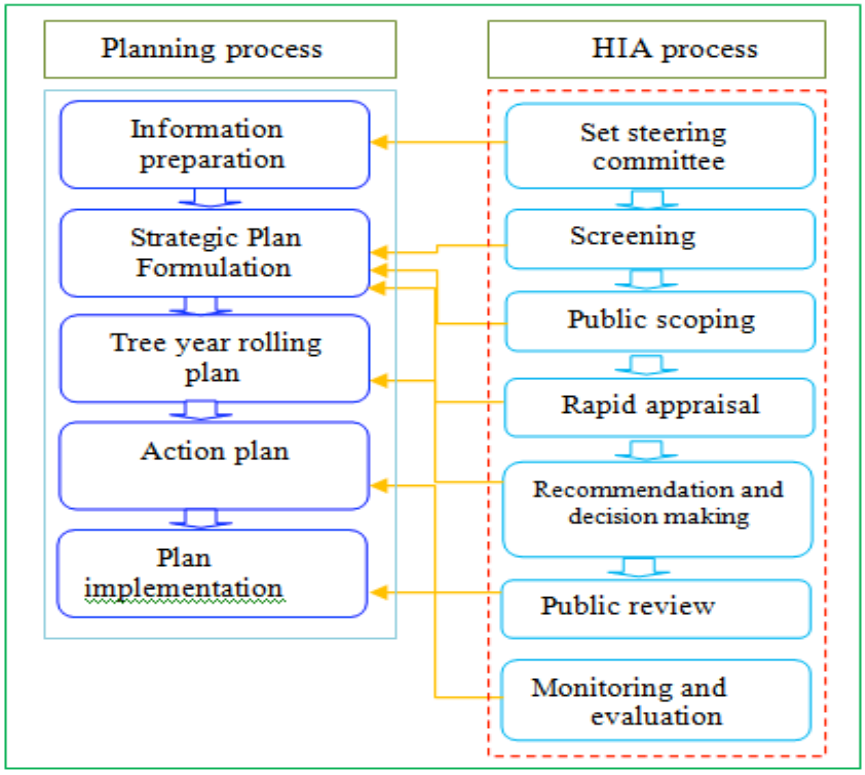

Figure 1: Model of Health Impact Assessment 1 (HIA Model 1)

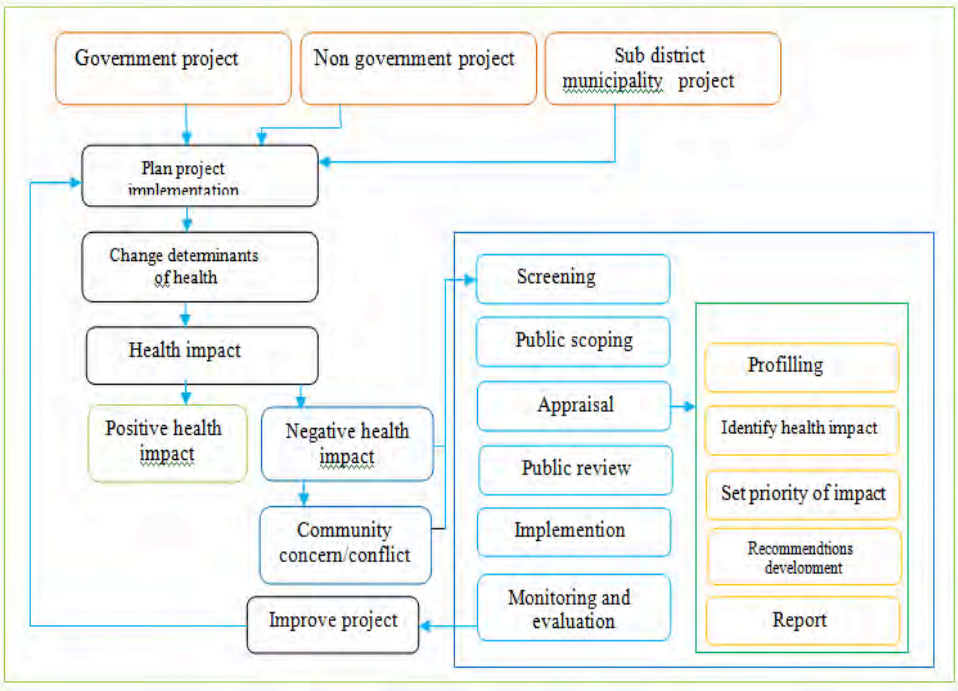

Figure 2: Model of Health Impact Assessment 2 (HIA Model II)

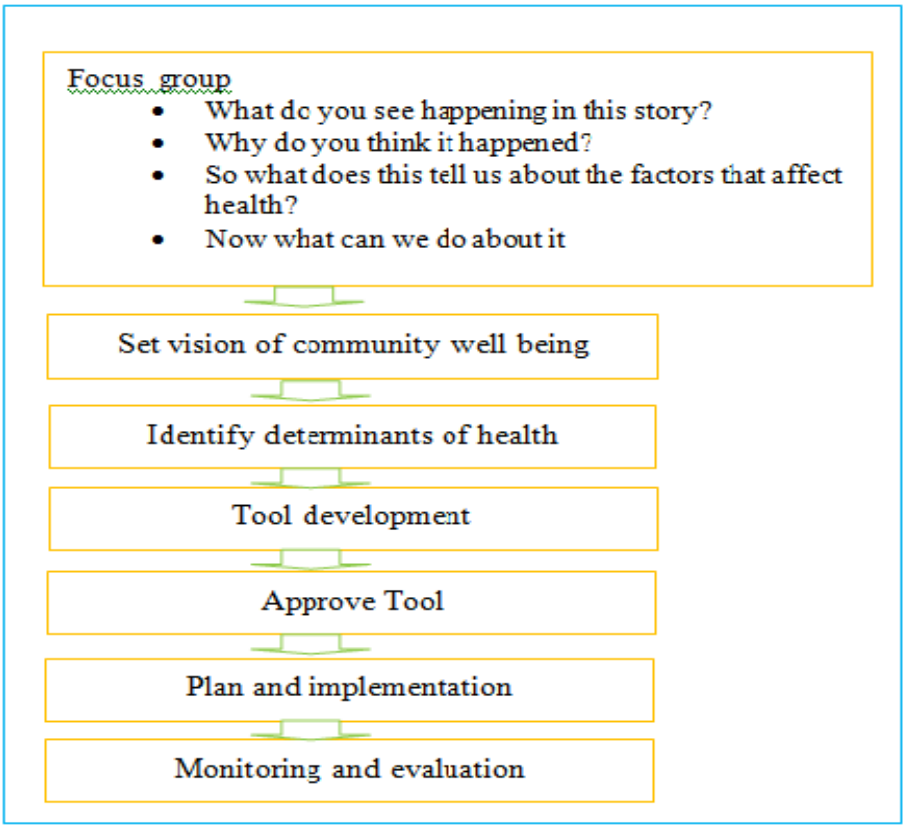

Figure 3: Model of Health Impact Assessment 3 (CHIA Model)

3.2 The second phase was specified model development, which aimed to study the enabling and barriers factors that influenced HIA in the sub-district municipality. A one to one interview of 23 key informants was carried out, and the results are as follows:

Regarding the enabling factors, the key informants felt that the enablers for conducting HIA in the sub-district municipality were:

- At the national level the legal instruments should be amended regularly; The New Constitution 2007 (section 67) and The National Health Act, 2007 (section 10,11).
- There is a National HIA commission of Thailand that encourages and supports the HIA system in Thailand.
- The Ministry of Public health of Thailand is developing HIA guidelines for local authorities (special issues such as solid waste management).
- For many local authorities, there are strengths in the community network, such as health volunteers, primary health care units, and other government and non-government organizations.

The barriers are as follow:

- Existing legislation does not support full assessment, including screening and public scoping, public review, especially during the public scoping stage, as mentioned in the law of Thailand.
- There is no HIA policy in the sub-district municipality.
- The HIA at the local level in Thailand is voluntary and is not regulated by te law.
- In Thailand, HIA is new; therefore HIA is not understood in the sub-district municipality.
- There is a lack of importance resources, HIA experts, no job descriptions in the organizational structure, lack of determinants of health data qualitative and quantitative tools.
- There is a lack of awareness of HIA.
- There is a lack of a health data baseline, social determinants of health data, and health outcome data.

The capacity/organizational support for HIA:

More than half of the 23 key informants said that the sub-district did not have sufficient resources, and that they could not support human, tools and HIA knowledge for conducting HIA in the sub-district municipality, and only half of them had sufficient finances for support. The keyinformants said that type of support need for HIA in the sub-district munucipality, should have HIA consultant team or facilitator team, Knowledge management and show success case study in the other area, seminar HIA practice, tools (screening and public scoping tools), guideline for HIA in the importance or special issue in thelocallevel such as solid waste management,conflict management, and waste water management.

From the results of this study it was found that there are three kinds of models for HIA. First is the prospective HIA model, which integrates planning processes. Second is the concurrent or retrospective HIA model. Third is the community health impact assessment model. All of the models will be used in the next phase of the research, which will use the scenario in the 4 sub-district municipalities for development of the HIA model. The 1st model will take for development the healthy public policy in the

Chalare sub-district municipality, Singhanakorn district, and in the Prig sub-district minicipality, Sadoa district, Songkhla Province. The 2nd model will take for waste water treatment from mat product in the Phanangtung sub-district municipality, Khuankanon district, Phatthalung province. The 3rd model will take for development the conservative tourism scenario in the Lansin sub-district municipality, Srinakharin district, Phatthalung Province. The important criteria selected for the 4 sub-district municipalities were the strengths of community participation and their willingness to participate in this research. Now this stage of the research is ongoing.

4 CONCLUSSION

HIA is a complex process, involving organizations with different cultures and charactistics. Therefore, before conducting an HIA in the sub-district municipality, it is important to understand the organizational factors that promote or limit the use of HIA. Although there have been many case studies of HIA at the local level world-wide, for Thailand, HIA at the local level is new and there are few case studies available. There is an absence of a nationally-defined regulatory and organization framework for HIA practice at the local level.

The key informants conclusion the factors which influecne for conducting HIA in sub district municipality were the national policy for HIA, HIA knowledge, lack of funding, and lack of tolls. The limitations of HIA were time frames, lack of funding, raising residents' expectations, and long lead times for proving health benefits[9]. WHO (1999) suggests integrating health impact assessment into the structure of the agency or into the routine work of the agency. This would allow for the assessment of the health impact achieved. Lack of support for the development and assessment of health impacts at the local level were the most important problem cites for HIA use for a healthy city in Trnava Slovakia[4]. Menzies (2007) has suggested that the factor for success of HIA in local government is selecting the best HIA steering committee.

Health impact assessment is an important tool which local authorities can use for healthy public policy. In Thailand, in the past decade there were many case studies about HIA at the local level. The key point of successful HIA development at the local level is the involvement of all stakeholders, beginning from the initiation process of health impact assessment. The resources available, such as time, expertise, data availability, and finances, will all influence the quality of the health impact assessment model constructed. Health impact assessment might also be only one of several factors that underpin the development of evidence-based health policy. Recommendations for encouraging HIA at the local level are as follows:

The national organization; the National Health Impact Assessment Commission of Thailand do as follows:

- Encourage the development of the potential of the sub-district municipality continuously;
- Coordinate with the Department of Local Government, Ministry of Interior of Thailand provide a system to empower local authorities;
- Support the development of learning to work together, learning about HIA and HIA-wide communications.

The result of this phase will be taken into the next phase, the 3rd and 4th phase, of HIA model development the for sub-district municipality in the Songkhla Lake Basin.

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Zhaoqing: A Study-Case of Energy-Saving Urban Design

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Abstract:

The guidelines of many international organizations (such as the European Commission) and contemporary scientific studies have called attention to the importance of city-scale planning with regard to energy-saving and environmental responsibility. The urban shape, as attested by the history of town planning, collaborates in reaching these goals: Scholars have shown how settlement morphology is related to environmental comfort and the city's energy urban balance via important 'physical' relationships (H/W ratio). In this way, architects and planners have improved both environmental behaviour and urban quality of living standards via typo-morphological solutions and the use of environmental data from the beginning of the urban design process.

In order to verify this theoretical approach, a case study from China has been used herein as a starting point. One of several projects for an academic course involving the development of a new train station area of Zhaoqing (P.R.C.) has been analysed and then modified through a three-step process. This modification has focused on the relationship between the original morphology and the corresponding urban microclimate, altering initial spatial and typological configurations to improve environmental performance.

The outcomes, shown via the software used, have confirmed the prominent role of good urban form in enhancing comfort standards and reducing energy needs of settlements. In addition, as many international organizations have advised, urban design must be considered a useful tool in planning the 'sustainable' city of the future, overthrowing the energy-related 'hidden costs' of bad design which can affect environmental and energy performance of buildings after their construction.

1.Introduction.

Despite the fact that today most energy-saving and environmental policies are pertinent to individual buildings, the instructions and guidelines provided by the ONU and EC in recent years have situated the city at the centre of such considerations. In 2006, the European Commission declared in its policy document 'Thematic Strategy on the Urban Environment': «[...]Urban areas play an important role in delivering the objectives of the EU Sustainable Development Strategy» (EU, 2006). This centrality of city-scale planning is encouraged by the city's size, positioned between region and building. The necessity of a switchover from a building-scale to a city-scale frame of reference has also been affirmed by scholars who have attested to the impact of city shape on both energy and environmental performance. Research carried out in recent years has demonstrated the necessity of making a leap in order of magnitude from the edifice to the entire urban organism to improve environmental comfort and energy efficiency. «A significant share of energy is, in fact, linked to the physical and functional relationships which are established, or may be established, among the various elements of the settlement, and which determine the city's shape and organization» (De Pascali, 2008).

Over the past century, this one-to-one deep link between urban morphology and energy supplies has determined the mutual development and decline of each, as testified by the history of architecture and planning, such that now one must wonder what the future of city shape holds, and more importantly, how the current urban form can be made to collaborate in building the future 'renewable' city.

Prominent studies on the relationship between urban morphology and its energy-environmental consumption have been ongoing since the 70s, after the oil crisis (S. Owens, 1986; R.L. Knowles, 1974; R. G. Stein, 1977). Results have highlighted the importance of certain 'physical' parameters on which designers and planners can work to improve urban comfort. This awareness has assigned relevant capabilities to urban design, already highlighted in 2004 by the European Commission, who declared urban design the ideal tool through which to intervene in spatial configurations to build more efficient urban forms.

This instrument also allows us to take into consideration the entire settlement, or an even broader area, overcoming the sectorial, piecemeal view of the city in favour of a more holistic approach which considers «the whole […] greater than the parts» (Scandurra, 1995).

2. The H/W ratio in urban morphology.

Among the physical parameters affecting the weather–environmental behaviour of settlements, scholars have identified the importance of H/W ratio (H= building height; W= façade width). According to these studies, values under this parameter affect urban energy balance, especially with regard to air temperature differences in the city centre, wind speed variation in the urban canyons, and the rate of solar radiation at ground level.

The main consequences of the aspect ratio on the weather–environmental performance of the settlement can be summarized as follows:

- H/W ratio and the *urban heat island*

according to the T.R. Oke equation:

$$[dt = 7{,}54 + 3{,}97 \ln(H/W)]$$

Thus, the aspect ratio is directly related to the intensity of the *'urban heat island'* (UHI). The UHI phenomenon refers to the increased air temperatures in central areas of the city, which spark a vicious cycle based on increased use of air conditioning systems and confounding

effect of their heat and gas emissions (Fig. 1). The high temperatures of the center city, in fact, have a tremendous impact on building energy consumption based on cooling needs. An Athens-based case study, carried out by M. Santamouris in 2001, found that electric energy requirements reached values three times higher than normal based on the UHI effect. Several studies performed in the USA (NASA and L.B.L.) (Santamouris, 2001) have studied urban temperature trends in several American cities. For example, the Los Angeles case study revealed a temperature gap during the last decade of 0.8 F, with a difference in cooling degree days equal to 92% more (1941-1970).

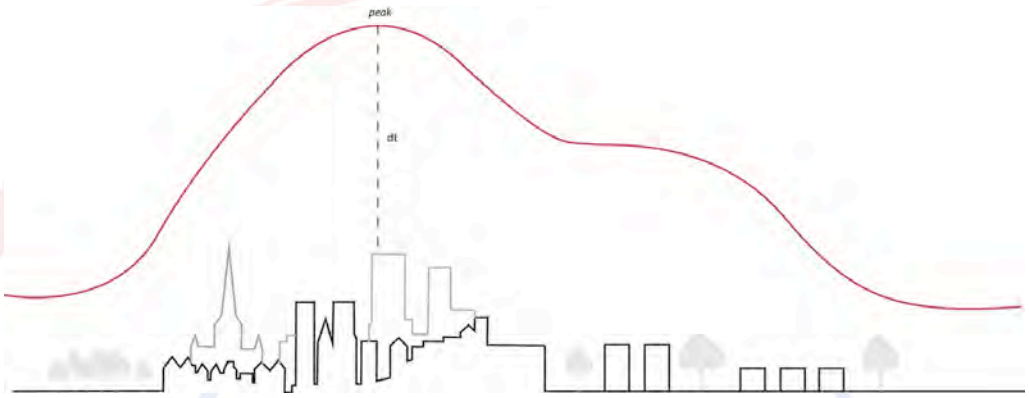

Fig.1. The urban heat island.

- H/W and the *urban airflow*

The roughness of a settlement influences wind flow inside the urban canyon. According to Oke, building geometry obstructs natural air movement, defining two different *layers* located above and below roof level (*boundary layer*; *urban canopy layer*).

Within the *urban canopy layer*, the relationship between urban geometry and wind direction impacts average wind speed and, consequently, the natural ventilation of the fabric. The orientation of the urban grid with regard to the main wind direction and the urban geometry identifies various wind regimes.

In the case that the canyon axis is oriented perpendicular to air flow, the secondary flow at ground level is strictly related to the aspect ratio, such that it will be reduced at greater values (> 0.65). «Naturally, this condition provides greater shelter to pedestrians from undesirable wind, but at other times may impede necessary ventilation of the urban space» (Erell, Pearlmutter, Williamson, 2011).

Differently, when the urban array axis is oriented parallel to wind flow, the secondary airflow circulation is a function both of width and façade distance. According to E. Neg: «For the air path to be effective, the width of the air path at the windward side should be at least, and on average, 50 per cent of the total widths of the buildings on both sides. The width needs to be increased when the heights of the buildings increase» (Ng, 2010).

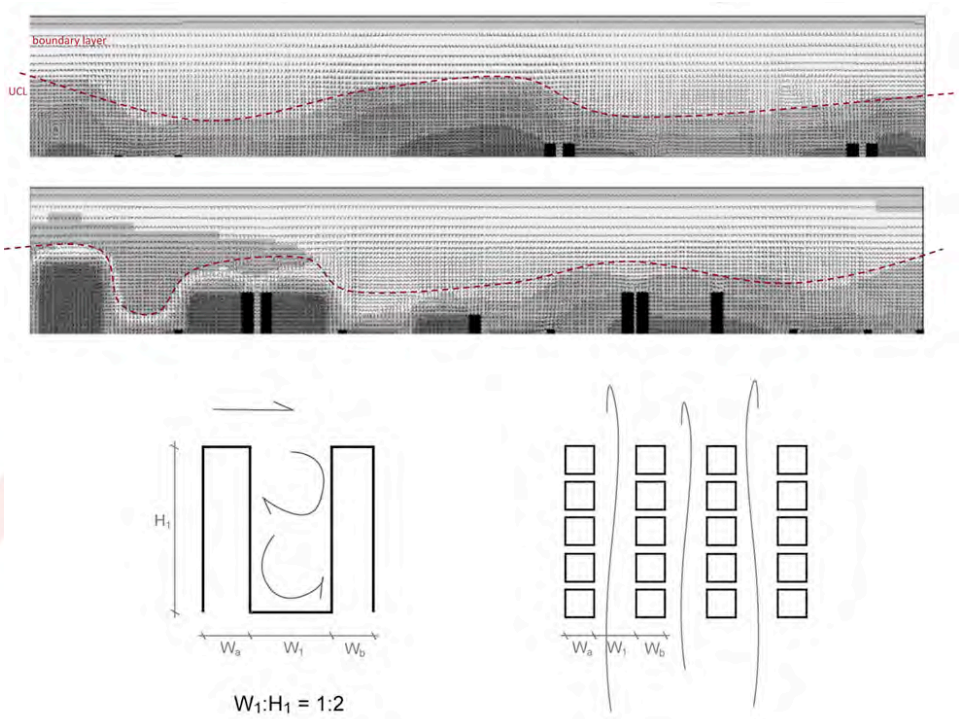

Fig.2. Urban airflows.

- H/W and *solar radiation access*

Regarding solar radiation access within the urban canyons, in addition to the H/W ratio, the location of settlements plays a prominent role in controlling daylight and sunlight. On the one hand, greater distance between building façades fosters the natural lighting of indoor and outdoor spaces, and improves building healthiness and citizen psychophysical well-being. On the other hand, in hot regions, greater distance may contribute to overheating of building surfaces, increasing indoor and outdoor air temperatures.

Research developed by A. Tsangrassoulis in 2001 (Santamouris, 2001), concerning the need for exploitation of natural lighting, linked urban geometries to latitude. The results suggested that designers should decrease H/W ratio in relation to increases in latitude, advising a practice already within the know-how of "good construction techniques".

Specifically, Tsangrassoulis identifies three optimal H/W ratio values with relation to three different latitudes, as reported in Table 1.

latitude	H/W ratio
40°	0.7
45°	0.58
50°	0.46

Tab.1. The conventional criterion of daylighting; A. Tsangrassoulis.

3. The Zhaoqing case study.

The impact (or potential) of urban form with regard to control and improvement of the urban microclimate has herein been tested via a case study regarding the northeast expansion of Zhaoqing City.

The main goals of the proposed work can be summarized as follows:

- To assay a potential practical method for bringing a site's weather and environmental data back into the urban design process from the initial stages;
- To devise a repeatable protocol which complements the design process. This tool joins the process throughout its complete *iter* via a continuous checking and monitoring of design performance, emerging from the early phase of main project criticalities.

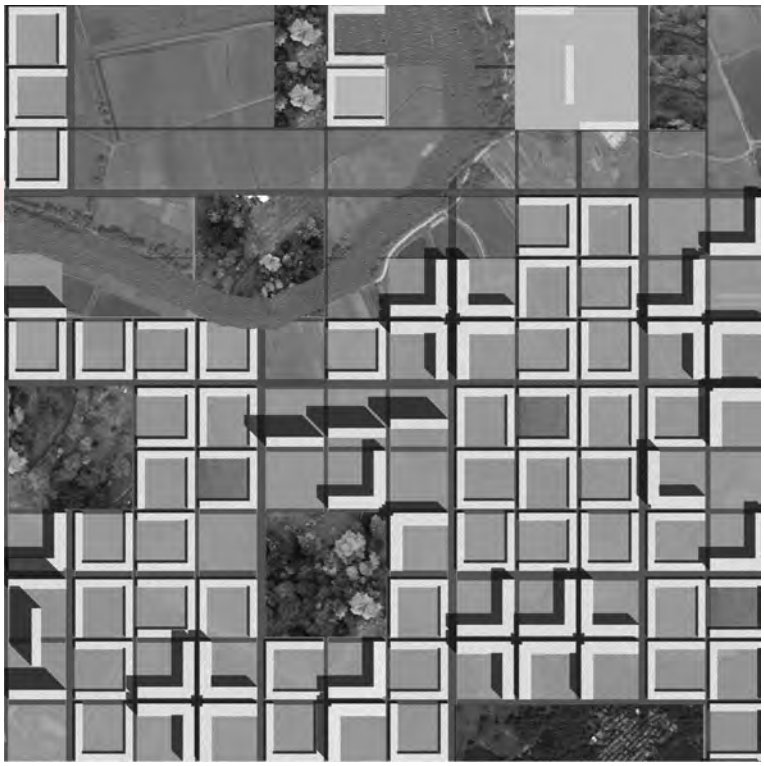

Fig.3. The initial urban design of Zhaoqing's new satellite town.
The master plan has been developed by F. Carta, M. Casu, C. Gaddari, M.A. Pani and F. Pinna.

3.1 The new satellite town.

The case study is in the preliminary stages of the urban design process in the construction of a new 45.000 inhabitant satellite town near the new high-speed train station in Zhaoqing, Guangdong Province (R.P.C.). The area under consideration is located in the city's north-east along the major infrastructural axis connecting the western China territories with the Pearl River Delta, China's economic and productive centre.

This work was developed by the Cagliari Faculty of Architecture in 2011 during a six-month academic design course, and was positively evaluated by an international jury.

The project divided the space on a square grid with sides 95m long, such that it covers a total area of about 1.4 km2 (1.200x1.200m). The grid gives with the terrain, breaking off and changing its size where it meets pre-existing local environmental and historical features, as it structures the urban space into macro-blocks with sides of 300m long. Each such block contains office and residential functions in accordance with the direction of the city plan, integrating the necessary services to satisfy the needs of the new expansion.

3.2 methodology of study.

The work is structured in a three-step process through which initial spatial configurations of the project have been analyzed, modified and then re-analyzed to estimate their weather and environmental behaviour.
The evaluations of the iteration between urban form and local features were carried out taking into consideration the two most critical days of the year (the summer and winter solstice) in relation to four environmental parameters:

- wind speed (m/s) and direction;
- temperature (K);
- relative humidity (%) and
- solar radiation (W/m2).

This analysis was developed with the help of two software: ENVI-met and Heliodon. Despite its limitations, ENVI-met allows the designer to evaluate the performance of the first three environmental parameters for each hour of the day through easy-to-understand thematic graphical maps.
Heliodon, by contrast, evaluated access to solar radiation, the shading phenomena and the sky view factor both for the building envelope and outdoor spaces, taking into account a simplified 3D model.

The local weather data were provided by the International Weather for Energy Calculation (IWEC). Although data were for Guanghzou city, the proximity of these two cities, approximately 98 km, allows us to approximate the weather conditions for Zhaoqing City.
In the table n.2 are reported the average data for june and december.

	Temp. (K)	**Rel. Humidity (%)**	**Wind speed (m/s)**	**Wind direction**
June	299	80	2.4	S
Dec.	288	60	2.5	N

Tab.2. Average weather data (Guangzhou). IWEC.

3.3. The three-step process.
Step 1. The urban design was analysed taking into account two macro-areas of study: the typo-morphological solutions of the project and their consequences on urban microclimate.
With regard to the first area of analysis, an abacus was built which yielded the main dimensional features of the three basic typologies used and of their spatial aggregations.
These latter can be summarized as follow:

- the “C” typology—9-12-15m—used to house residential functions. The aggregation of these buildings determined inner courts with sides equal to the grid dimension (95m).
- The “L” typology, 30-60m high. These buildings contain offices and business and financial functions.
- Rectangular towers, 100m high. Executive and office districts are also housed in these towers.

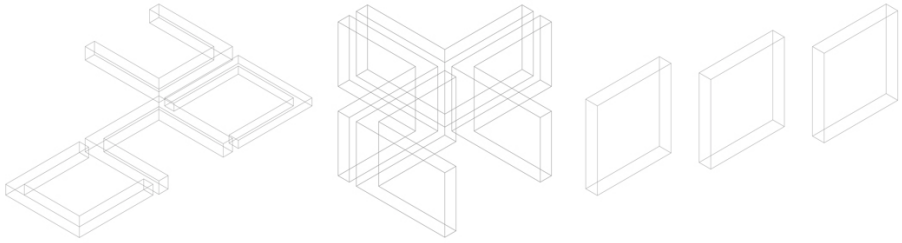

Fig.4. Basic typologies and spatial aggregations.

As we have seen above, values assigned to the aspect ratio have a significant impact on the urban microclimate. To better evaluate the consequences of the H/W ratio, the main urban spatial configurations and their aspect ratio values were analyzed and synthesized, as shown in the figure below.

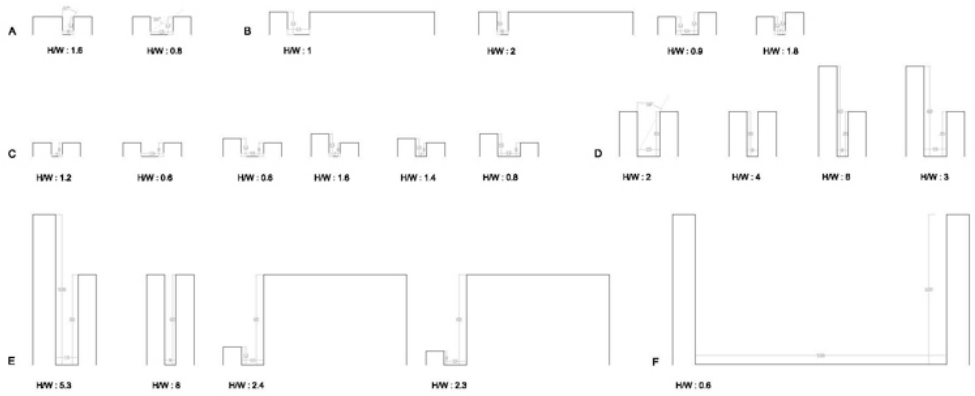

Fig.5. The aspec ratio values of the original project.

The main critical point which emerged during the first phase of analysis of the project can be summarized as follows:

- The grid's size and the use of a typology closed on three sides ("C" typology) obstructs the penetration of air flow into the urban texture, especially for building heights greater than 9m.
- The juxtaposition of buildings over 30m (60-100m) creates a barrier to air, especially along the southern side. The cross-shaped group arrangement hinders sunlight penetration with consequences in terms of both indoor natural lighting and shadowing. The latter phenomenon affects both the building envelope and the outdoor public spaces.
- Both the above points affect humidity levels, very high in the summer (80-95%).
- The road axis, oriented N-S along the direction of the prevailing winds, is able to channel air only for the H/W ratio contained in value 2.
- The sunshine of both the inner courtyards and the vertical surfaces improves if the C typology buildings are oriented along the N-S axis and the "L" typology buildings along a N-E/N-W axis.
- In some areas, the H/W ratio reaches very high values, between 4 and 8, unfavourable for both natural ventilation and lighting of indoor/outdoor spaces.

Step 2. The initial choices of the urban design which had been critically evaluated for environmental comfort were changed with the intent of improving design performance. The

modifications were studied in order to comply with certain general settings of the original project such as the utilization of the square grid and the north–south orientation, strictly linked to the local traditional culture.
The interventions were aimed at implementing the penetration of air flow into the urban fabric with the purpose of reducing the humidity level, which can be particularly high in a tropical context such as that in Zhaoqing. To achieve these goals, this case study worked primarily on typological solutions and spatial configurations. It reduced maximum building heights (Roaf, 2010), favoured continuous front chipping, and guaranteed paths for air path flow. The new design worked on buildings defining three main layers characterized by different altitudes:
0-9 m: this first area features a base which redefines the spatial relationships between indoor and outdoor building spaces. The building arrangement maintains internal courtyards that double each building's size, and, where possible, orients these along the N-S direction of the prevailing winds.
9-40m: this second area overlaps the previous base, and is designed with particular attention to the ventilation and shading of adjacent spaces. The ratios established are constantly checked for both surrounding buildings and open spaces.
Finally, the square towers are at a height of 54m. These answer the dual purpose of absorbing missing volume and of reintroducing «prominent nodes» (Lynch, 1960) to facilitate citizens' orientation in the urban space.

Phase 3. This last step repeats the initial analysis process of the previous urban proposal to evaluate its behaviour and to compare it to the original plan. The weather–environmental analysis takes into consideration the most disadvantageous time of the year which emerged in step 1: the summer solstice.

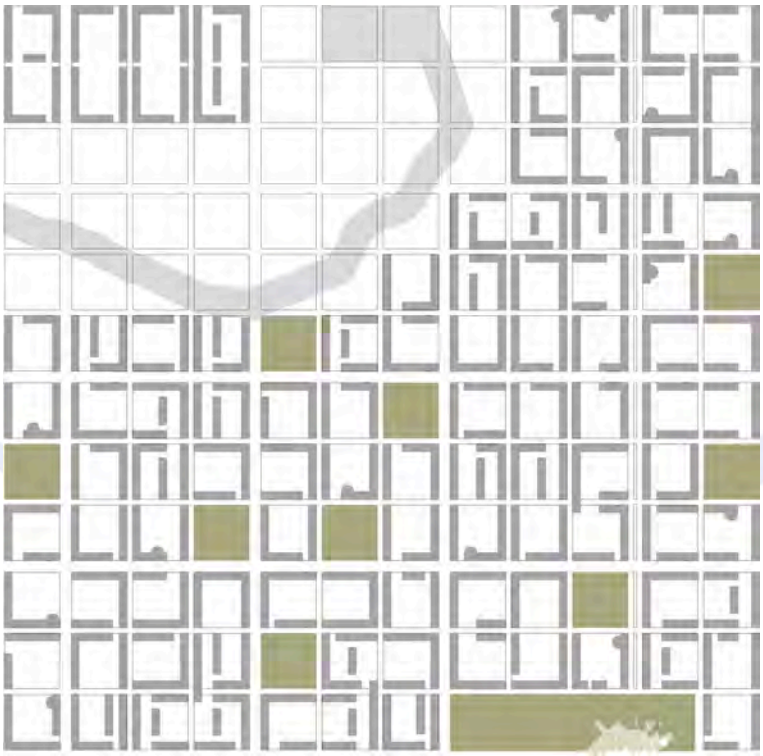

Fig.6. The second urban design proposal.

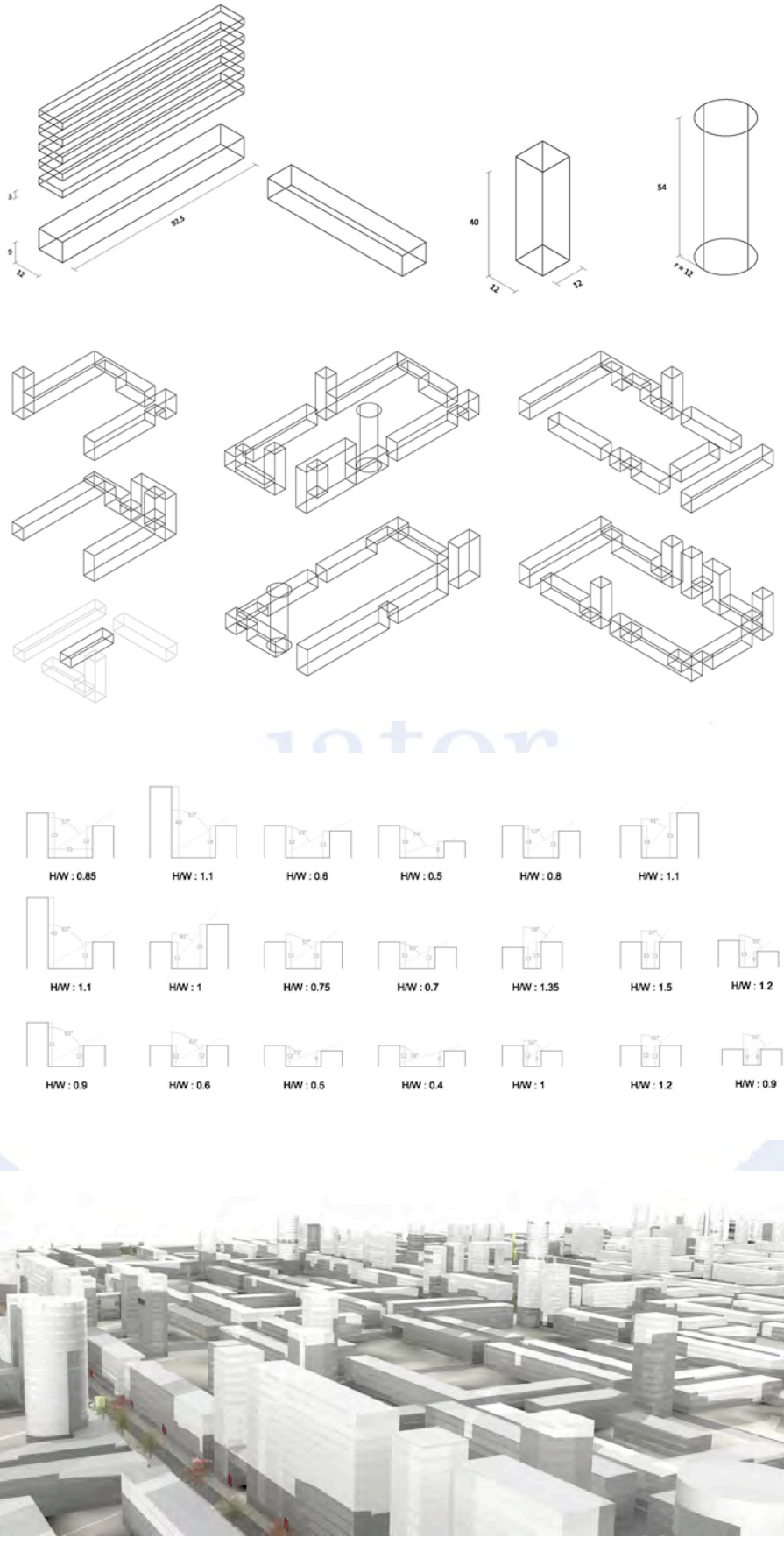

Fig.7. The second round of typo-morphological solutions and spatial configurations.

Below, the new aspect ratio values and an overall view of the project.

4. The results of the intervention.

The results obtained in the third phase and performed after the changes to the original design confirmed the validity of the transformations.

The main benefits are summarized below:

- The natural ventilation in the urban fabric has improved: on the street the wind speed remains up to 1.5–2 m/s. According to Givoni, a wind speed of 1.9m/s over the body is enough to ensure a neutral thermal sensation condition at 28°C (Ng, 2010). The overall reduction in building heights and the increase in courtyard size have both improved the natural ventilation of the blocks, guaranteeing a minimum wind rate of between 0.5-1.5 m/s.

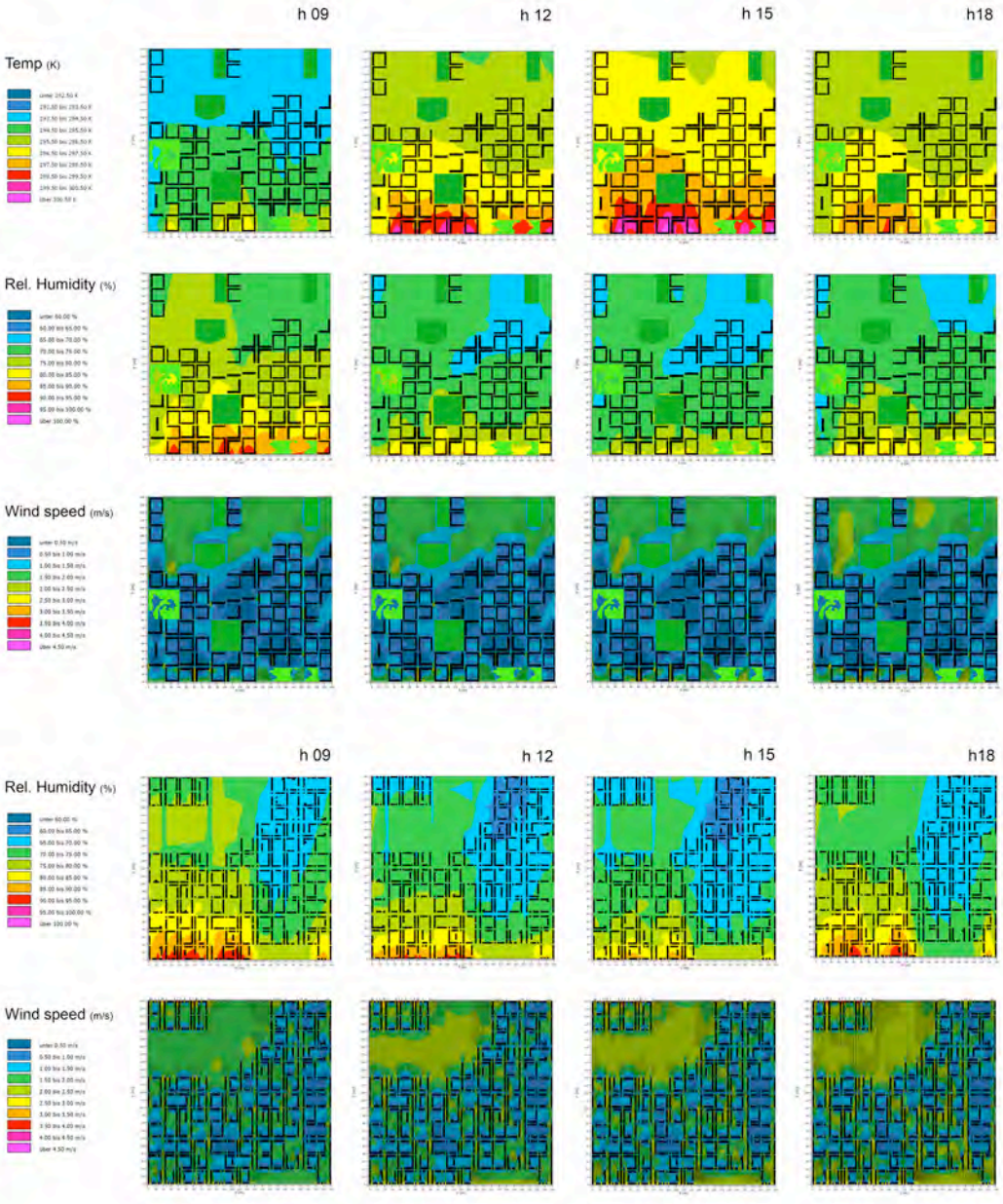

Fig.8. ENVI-met results for the original master plan (upon) and the new proposal (below). Maps show the parameter trends during the prime hours of 21st June.

- Similarly, with regard to relative humidity, the levels achieved during the day have been improved, especially in the east part of the project, where values have been decreased by 10–15% compared to the initial situation.
- The increase in the built area of approximately 15% has produced an increase in daily solar radiation of 30% on the 21st of June. This result can be explained in part based on the major attention paid in the design process both to surface orientation and to building façade relationships (H/W ratio).
- The continuous monitoring of this ratio has successfully contained its values below the maximum threshold of 1.5 for the analysis.

Microclimatic information in relation to the two planning solutions, provided by software, has been incorporated into the bioclimatic chart of V. Olgyay to evaluate degree of comfort. The environmental parameters entered are relevant to the 21st of June. As may be noted, the two distinct spatial configurations correspond to two microclimate conditions that, even if similar, reaffirm once again the effectiveness of design transformations. In fact, microclimate performance arising from new typo-morphological solutions approaches the comfort zone, assuring comfortable conditions during some hours of the day and an overall improvement as compared to the original proposal.

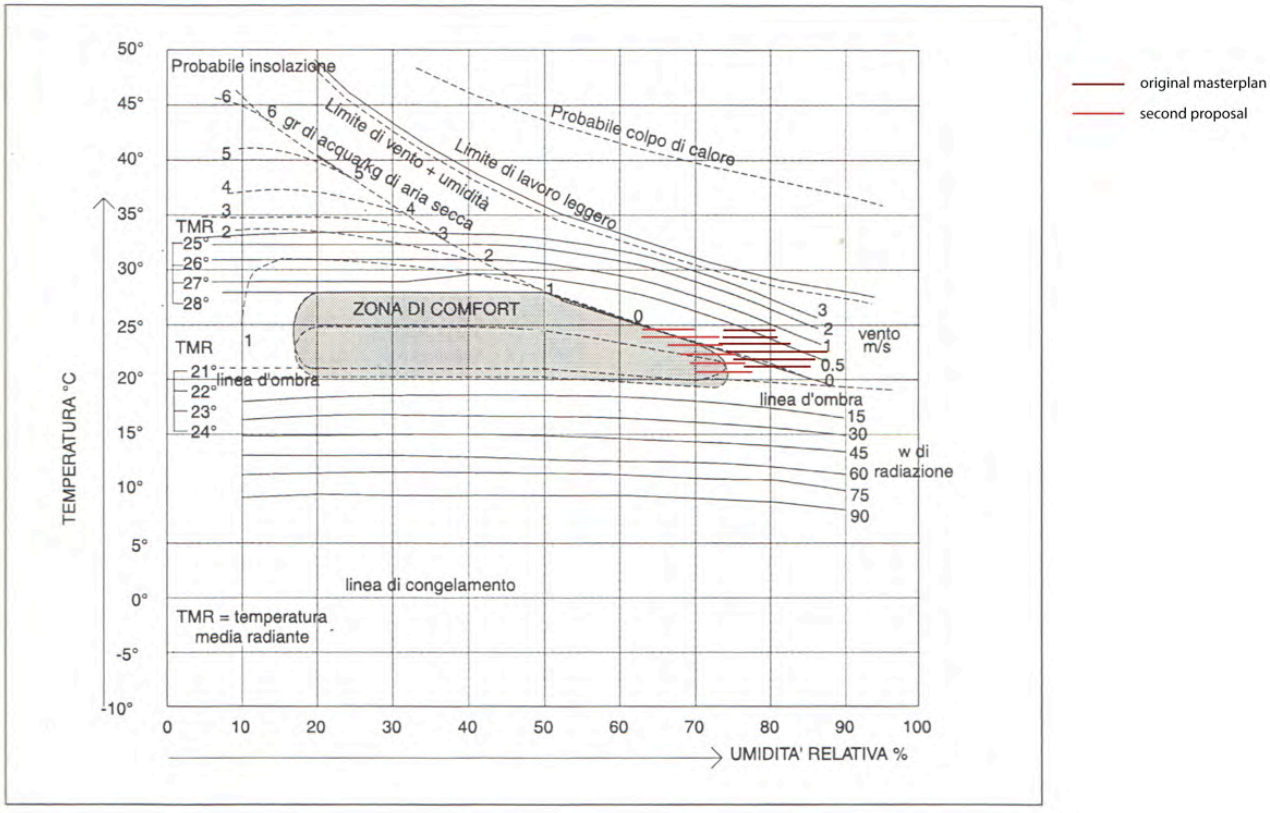

Fig.9. The bioclimatic char of V. Olgyay.

5. Potential renewable energy.

The increase in daily solar radiation on surfaces makes it possible to convert a portion of that radiation to satisfy the electrical energy requirements of buildings. Considering the difficulties of energy data retrieval for offices and services, we focus on residential energy production and consumption. The aim of this work is to ascertain whether the direct solar radiation

received on residential building roofs is sufficient to satisfy the energy requirements of the building's residents.

Building	Area (m^2)	direct solar radiation (kWh/year)	fattore rid.	Tot. direct solar radiation (kWh/year)
H9	68.928,50	129.792.960	0,32	41.533.747
H54	4.657,80	9.262.356	0,32	2.963.954
H40	23.457,60	44.119.591	0,32	14.118.269
H25	17.232,40	33.240.013	0,32	10.636.804
H18	27.835,10	52.333.094	0,32	16.746.590
H15	69.379,10	130.380.786	0,32	41.721.851
H12	89.111,90	169.381.520	0,32	54.202.086

Tab.3. Annual direct solar radiation on building roofs.

Tot. Building area (m^2)	Annual direct solar radiation (kWh/year)	Annual direct solar radiation/m^2 (kWh/m^2 year)
300.602	181.923.302	605

Tab.4. Annual direct solar radiation on the roof per square meter.

The solar radiation received on the roof was measured by Heliodon for one year (365 days). Results obtained considering a clear sky the entire time of measurement have to be decreased by a reduction factor of 68%. This factor has been determined based on a comparison of the average IWEC monthly direct radiation statistics with those of Heliodon.
According to the initial choices of the urban design, the residential functions are mainly held in "C" typologies of 9-12-15m height; total roof surface and energy consumption are summarised in Table 5. Energy consumption evaluations have taken into consideration the ClimateHouse A categories, which attest to consumption of 30 kWh/m2 year for buildings of the A class in Italy. Multiplying single consumption first for the building floor area and secondly for the number of floors, we can evaluate the global residential energy requirements for each typology (9-12-15m).

Building	floor area (m^2)	floor n.	area (m^2)	ClimateHouse A standard (kWh/m^2 year)	Tot. house energy consumptions (kWh/year)
H9	68.929	3	206.787	30	6.203.610
H12	89.112	4	356.448	30	10.693.440
H15	69.379	5	346.895	30	10.406.850

Tab.5. Annual energy requirements for residential buildings.

The energy production, on the other hand, has been evaluated taking into account the total direct solar radiation on a residential roof. Considering the total energy stored over 365 days and the total roof area of the buildings, we found a direct flux equal to 605 kWh/m2 year. This figure has been multiplied to account for the total roof surface of each typology, yielding a direct potential solar radiation of about 137.500.000 kWh/anno.

The current photovoltaic technologies active on the market are capable of capturing and transforming into electricity only a small portion of the received direct solar flux, between 10% and 20%. This gap depends on *pv* panel materials and features: an amorphous silicon panel requires less energy to be produced than a monocrystalline/polycrystalline silicon one, but its energy conversion ratio fluctuates between 10 and 14%. On the other hand, the monocrystalline or polycrystalline silicon panels are more energy-intensive to produce, but their efficiency reaches 20-22%.

Building	roof area (m²)	Annual dir. solar rad./m² (kWh/m² year)	Roof dir. solar rad. (kWh/year)	*pv* panel efficiency (13%) (kWh/year)	BOS efficiency (85%) (kWh/year)	% energy requirement compensation
H9	68.929	605	41.702.045	5.421.266	4.608.076	74%
H12	89.112	605	53.912.760	7.008.659	5.957.360	55%
H15	69.379	605	41.974.295	7.555.373	6.422.067	61%

pv panel efficiency (18%) (kWh/year)	BOS efficiency (85%) (kWh/year)	% energy requirement compensation
7.506.368	6.380.413	1%
9.704.297	8.248.652	77%
7.555.373	6.422.067	62%

pv panel efficiency (20%) (kWh/year)	BOS efficiency (85%) (kWh/year)	% energy requirement compensation
8.340.409	7.089.348	1,15%
10.782.552	9.165.169	85%
8.394.859	7.135.630	69%

Tab.6. Annual electric energy production by three different *pv* panels.

The calculation of potential renewable energy produced by building roofs has taken into account both kinds of pv panel: an amorphous silicon panel with 13% efficiency and two polycrystalline silicon panels of 18-20%. Results are shown in Table 6. Obviously, the amorphous silicon type produces less electricity than the others, but it is both energetically and economically less expensive and is able to satisfy at least 55% of the residential buildings' consumption needs (H 12). In the case of the H9 building, by contrast, this value improves, accounting for 74% of the total one-year energy consumption.
With regard to the polycrystalline silicon panels, the difference made by the higher energy production efficiency of between 18% and 20% is especially noticeable for the 12m buildings, improving energy production by 8%, and covering between the 77% and 85% of annual energy requirements. The H9 buildings, by contrast, would produce a one-year surplus of +1–1.15%.
Any such energy surplus could be channelled into the urban electricity network and be used to feed other buildings and services. The energy requirements of office and service industry buildings are not easy to define. Though no definite annual figure can be proposed, requirements can be supposed to exceed residential levels; recent research of the ENEA R.S.E. (2009) assumed for Italian offices a consumption standard of 80 kWh/m2 per year, a value three times higher than residential requirements. The size of the energy requirements noticeably reduced the potential solar energy contribution of office and service industry roofs to the annual energy balance.

This reflection suggests, once again, that designers should broaden their attention to encompass how buildings of various sizes may function in the City through the "smart grid" system. Through such a system, the building's energy production is brought into the urban electric network and channelled in real time where requested. In this way, we can suppose that we may move, during the day, a portion of the renewable energy produced by residential buildings to offices and business districts, and vice versa, thus meeting a greater share of energy requirements.
In fact, on the strength of scholarly findings, we may say that renewable sources will allow a switchover from a territorial centralized system to a new, dispersed and consumed-on-the-spot form of energy production. Thus, cities (or urban blocks) may transform themselves into self-sufficient islands able to produce their energy requirements autonomously. Energy surplus in the 'island' may be poured into an urban smart grid system and simultaneously used by other consumers or stored. According to L. De Santoli, «each isle could be connected with other islands to form an "energy district". All this changes the design approach into the urban design size and different urban, spatial configurations».

6. Conclusion.

The positive results obtained via this three-step process confirmed not only the validity of the project interventions, but the effectiveness of the design procedure. The integration of a continuous check system, operating hand in hand with the design process, assists the designer in selecting and editing typo-morphological solutions to allow for the definition of a more efficient urban form even in the early stages of the project.
Although energy-saving policies today mainly address individual buildings, such measures on their own are unable to ameliorate the discomfort caused by an inefficient urban design which rebounds upon itself, raising energy and environmental costs.
The assistance rendered by the software used in this study confirms it to be an extraordinary tool by which to qualitatively assess trends stemming from initial choices, directing the design towards the overall improvement of its performance. Despite the software's relevant limitations, the results demonstrate the method's validity and its applicability in diverse forms and contexts.
Finally, the potential for increased use of renewable energy also calls designers' attention from the building to the city scale, confirming the necessity of overcoming a sectorial view of the settlement in favour of a vision of a more holistic "smart city".

7. Acknowledges.

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Sustainable Management of Coffee Agroforestry Systems in Colombia

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Abstract:

Coffee is the main export of Colombia and is generated 80% of the volume as wastes during processing. Coffee agroforestry systems also have other crops and livestock components that generate considerable quantities of organic waste, susceptible to profit taking into account that they are reusable source of nutrients and energy. A management alternative is composting. Organic material is composted mixture (coffee pulp, banana, cattle and hens manure), from coffee farms located in the department of Cundinamarca. Experimental units were placed in the field and under controlled conditions (microcomposting), used a completely randomized design, data processing we used the SAS statistical package 9.0 version in MEANS. When a significant effect (alpha 5%) were performed by Tukey means test. T test was used for paired samples. In the obtained compost quality indicators were evaluated microbiological and chemical. For the identification of microorganisms of fecal origin MPN technique was applied. Parameters such as OM, OC, macro-and microelements were determined in the Soil Laboratory of the University of Tolima. The treatments met minimum health values as a prerequisite for marketing, as well as a mature compost as the C:N final ratio between 10 and 15. Mixtures 1 and 3 were the best content of nutrients. There were no significant differences between field composting and microcomposting, indicating that results could be extrapolated in controlled environments to field conditions.

INTRODUCTION

"The composting is the aerobic biological process by which microorganisms act on the biodegradable organic matter (crop residues, animal waste and urban waste), organic fertilizers can obtained by composting for agriculture" (Larney & Hao, 2007).

According to Bernal et al., (2009) efficient composting requires control of many factors to avoid problems such as odors and dust, and also to obtain an agricultural quality product. In recent decades, research has focused on the study of complex interactions among physical, chemical and biological processes that occur during composting. However, "the control of parameters such as bulk density, porosity, particle size, nutrient content, C/N ratio, temperature, pH, moisture and oxygen delivery have proven important for the optimization of composting because to determine the optimal conditions for development and microbial degradation of organic matter" (De Bertoldi et al., 1983; Miller, 1992; Das y Keener, 1997; Richard et al., 2002 y Agnew & Leonard, 2003).

One of the major environmental problems associated with the production of coffee is the generation of pulp. Pujo et al. (2000) indicate that in the mature coffee processing generates more than 80% of the volume as waste, and every residual element is in a different degree, a risk to the environment. In the coffee is only used 9.5% of fruit weight being 90.5% (Table 1) in different organic waste mass (Street, 1977). This suggests that it is probably the time to introduce some changes in the culture to replace the waste for recycling. In the coffee farms there is another series of recyclable organic materials: coffee growing normally associated with banana plants, which in addition to the fruit of rejection can exploit the pseudostem and leaves, the cultivation of coffee is also produced litter and wood (Rodriguez, 1999). All those with an important nutrient that could well be reused in the system using organic fertilizer applications or component of the diet of animals.

Tabla 1. Residues obtained in the benefit of a kg of coffee cherries

Processing	Loss (g)	Obtained Residue
Pulping	394	Fresh pulp
Degumming	216	Mucilage
Threshing	35	Parchment
Drying	171	Water
Roasting	22	Volatile
Beverage preparation	104	
Cumulative loss	942	

In the coffee zone, production of organic waste from livestock activities is equally significant. Estimates of Garcia (1993, cited by Estrada & Peralta, 2001) account for manure in the order of 5.5%, 8.5% and 10% of the alive weights of birds, pigs and cattle, respectively. Considering the coffee production, livestock and other agricultural and animal components existing in the coffee region of the Cundinamarca, Tolima and Caldas departments, it is logical to infer that the study of organic mass in these systems is critical to improving processes nutrient recycling. In Tables 2 and 3 can be some of the major areas of production and generating organic mass present in the study area.

Tabla 2. Estimated production of parchment and pulp in the municipalities of study.

Municipalities	Área (ha)	Media production (d.p.c.*)	Yield (c.p.s.*/ha)	Estímate Pulp Production (Kg)
Fusagasugá	1.850	65.894	30.2	2.350.450,82
Fresno	92	5.152	56.0	137.900,00
Icononzo	2.257	72.224	32.0	1.933.169,57
Líbano	300	16.800	56.0	449.673,91

d.p.c.* (dry parchment coffee)

Tabla 3. Production of cattle and estimated solid stool in the municipalities of study.

Municipalities	Livestock Área (ha)	Total Animals	Animal Carry (GCU*/ha)	Estimate Manure production(Ton)
Fusagasugá	2.056	5.607	0.5	10.811.447,25
Líbano	6.642	6.340	1.0	11.454.795,00
Fresno	3.365	8049	2.4	14.542.530,75
Icononzo	11.695	8303	0.7	15.001.445,25

GCU* (Great Cattle Unit)

METHODOLOGY

This research began with the stage of diagnosis and quantification of organic waste produced in farming systems located in thermal levels between 1000 and 2000 m.a.s.l of Cundinamarca and Tolima, for it was used the information obtained in two projects. The first named, Development and Technological Innovation in Ecological and Efficient Livestock in the Province of Sumapáz in the Productive Sectors and Educational (Universidad de Cundinamrca-UDEC), from which we analyzed the database and selected 202 farms located in the towns of Fusagasugá, Tibacuy, Arbelaez, Pandi, Venice, Silvania and San Bernardo.

In the mentioned project evaluated the systems management technology of cattle production and estimated the amount of feces produced annually per farm (Table 4), which is to make calculations based on stool number and type of animals on the farm, alive weight in adulthood and the time spent on the farm.

Tabla 4. Manure waste produced by dry matter (D. M.)in cattle farms average thermal floor (1000-2000 m.a.s.l) of Cundinamarca

		Types of farms		
	Component	**C1***	**C2***	**C3***
Agricultural Wastes in D. M. (ton/ha/year)	**Coffee**			
	Pulp	0,2	0,7	0,3
	Cherry	0,1	0,3	0,1
	Mucilage	0,1	0,2	0,1
	Musa			
	Steam	7,7	5,6	86,9
	leaves	2,5	1,8	28,5
Animal Wastes D. M. (ton/year)	Pigs	6,5	25,9	6,3
	Cattle	53,4	14,6	12,2
	Hens	0,4	2,0	0,3
TOTAL		**69,4**	**76,9**	**48,2**

*C (conglomerate1, 2 y 3)

The second project discussed is called Mass and Energy Flow in Farms Coffee Zone: Linking Farmer rationality and Materials Recycling and Energy (Universidad del Tolima - Red Alma Mater), which was developed in the municipalities of Líbano, Fresno and Villarica in Icononzo (Tolima). According to the results of the study, it founds that different types of farms are the most common substrates: coffee pulp, waste from cattle (cattle manure), pigs (pigs manure) and poultry (chicken), residues of straw and fodder plants. Table 9 shows an estimate of residual organic material in livestock production of the coffee region of northern Tolima.

Considering the major organic waste and the information obtained from the studies were implemented with the substrates available composting on farm as part of the extension stage of the projects mentioned above. In order to make monitoring in a controlled environment, established a small experimental scale replica of the on-farm composting established. To do this, we designed a test microcomposting, located in a position (temperature, humidity, altitude) similar to the location of the farms. The experimental site provided for the establishment of the Quinta Villamaría, situated in Fusagasugá municipality. We evaluated three mixtures (MZ1, MZ2, MZ3) determined by the C/N ratio (Table 5).

Tabla 5. Proportion of organic materials in mixtures to evaluate according to the relation C / N

Organic Material	C/N	Humidity (%)	**Mix 1*** (Kg)	Dry matter	C/N	**Mix 2*** (Kg)	Dry matter	C/N	**Mix 3*** (Kg)	Dry matter	C/N
Coffee pulp	8	60	15	6	0,48	15	6	0,48	10	4	0,32
Cattle manure	20	15				15	12,75	2,55	20	17	3,4
Hens manure	15	15	15	12,75	1,913				20	17	2,55
Banana	35	80	5	1	0,35	5	1	0,35			0
Leaves	60	20	50	40	24	50	40	24	50	45	27
C/N			85		**26,74**	85		**27,38**	100		**33,3**

NOTE: mix composition
Mix 1 = coffee pulp + coffee leaves + Banana + Hens manure
Mix 2 = coffee pulp + coffee leaves + Banana + Cattle manure
Mix 3 = coffee pulp + coffee leaves + Hens manure + Cattle manure

We used a completely randomized design with repeated measures structure in time, considering each compost as an experimental subject, with different evaluation times. The equation that defined the model is:

$Y_{ijk} = \mu + \tau_i + \delta_{ij} + P_k + (\tau*P)_{ik} + \epsilon_{ijk}$

Y_{ijk} = observed value of the response variable in the i-th compost, the j-th substrate and the k-th sampling

μ = general average

τ_i = j-th sustrate effect

δ_{ij} = Random error of subjects, covariance between repeated measures within compost

P_k = k-th sampling carried effect

$(\tau*P)_{ik}$ = interaction between sustrate j-th and sample k-th

ϵ_{ijk} = Experimental error

Microbiological analyzes of samples were performed in the Microbiology Laboratories at the Universidad de Cundinamarca, in Fusagasugá. Chemical analyzes were performed at the Soils Laboratory of the Universidad del Tolima

According to the optimum C/N ratio (25-30), for starting the composting process was necessary to prepare mixtures. To improve this ratio further litter was used, obtaining results close to those required. Plant residues with high content of lignin and other polyphenols, are more resistant to decomposition poor materials rich in these compounds and nitrogen compounds decompose quickly. In this regard Jenkinson (1992) argues that litter of tree species with high C/N and polyphenol-rich decomposes relatively slowly, compared with the leaves of plants rich in nitrogen and soluble carbohydrates but low in polyphenols. The litter was obtained from coffee plants and was used primarily to increase the C/N in the mixtures, as these contain high levels of carbon (40-50%) and other nutrients (Khalid & Anderson 2000; Lim & Zaharah 2000). The parameter C/N ratio is associated with microbial dynamics in the substrates used, according to Melendez (2003), by varying mixtures in chemical composition of microbial populations are stimulated and therefore optimize the composting process.

Composting in field

A specially designed for each substrate and compost mixture to assess three replicates in each experimental unit on three farms in Cundinamarca, making dump twice a week. Depending on the amount of organic matter produced by the coffee farms under study was chosen to be composted substrate type in each of these (Fig. 1).

Figure 1. Coffee farm in La Honda Fusagasugá, processing samples in the field to generate composting processes of different treatments.

The assembly of beds was designed by drying and sieving to obtain uniform particle size on plastic beds were constructed of 5.0 m long x 5.0 m wide x 0.80 m high with a capacity of approximately one ton. Water was applied to raise the temperature of the bed (Jaramillo, 2002). These composting were built to compare with the final products microcompostong (day 90) by bromatological analysis.

Microcomposting

With the substrates on farms were prepared in sheeting microcomposting 0.80 x 1.20m, which were filled with approximately 45 kg of each of the mixtures already determined (Fig 2).The substrates were obtained from different farms and were transported to a particular tract (Quinta Villa María), close to the Universidad de Cundinamarca.

Figure 2. Disposition of microcomposting in controlled environments.

Coliform Bacteria Determination

For the determination of potential pathogens from fecal remains of decomposition were tested for total coliforms and fecal coliforms and identification of *E. coli, Salmonella* and *Shigella* by the Most Probable Number method (MPN), in making the day 90 for treatments. To check the amount of pathogenic organisms of fecal contamination characteristics associated with minimum levels of quality for marketing, descriptive statistics (central tendency), comparing the data obtained in laboratory with the maximum values allowed.

Chemical indicators (pH, OM, CO, ON, TN, C/N ratio, CEC, Ca, Mg, K, Fe, Mn, Cu, P, S and B) for each substrate were treated with the application of descriptive statistics MEANS procedure of SAS version 9.0, also evaluated the effect of substrate with the GLM procedure of SAS version 9.0 and made comparisons Tukey unplanned for treatment means. Additionally T test was used for paired samples in order to compare the means of physico-chemical variables between field composting and microcomposting.

RESULTS AND DISCUSSION

As a result of the presence of *Escherichia coli* colonies were observed fermenting typical silver and black color red. In Colombia there is no regulation regarding the amount of pathogenic organisms of fecal contamination characteristics associated with minimum quality index for the marketing of fertilizer derived from composting processes. According SDCQC (2002) and NCh2880 (2003), the amount of pathogens should be less than <1000 MPN / g, according to this value the substrates tested complied with the maximum amount of fecal pathogens (Table 6).

Table 6. Number of pathogens characteristic of fecal contamination during the composting process in mixtures.

Treatments	Presumptive test MPN/g	Confirmatory test for total coliforms MPN/g	Test to *E. coli* MPN/g	Maximum value allowed by international regulations
Mix 1	150	9	9	<1000 MPN/g
Mix 2	9	16	16	<1000 MPN/g
Mix 3	37	37	37	<1000 MPN/g

This result suggests that during the composting process in the treatments, the temperature values reached 46°C. According to Pierre et al., (2009) temperatures of 45-50°C are considered appropriate to eliminate pathogens, parasites and weed seeds, as the values reported in this study.

Chemical parameters

Mixtures 1 and 3 showed the highest contents of organic matter (OM) with 37-38% and organic carbon (CO) with 21.32%. Total N content was similar between treatments (Table 7), the highest content of nutrients shown in mixtures 1 and 3, is attributed to the hens manure, coffee pulp and coffee leaves. According to that reported by Liang et al., (2003), these materials are rich in macro and micronutrients. The hens manure is the main source of nitrogen, however, the concentrations of nutrients in this type of material varies with the origin of the manure. The best chicken by Raviv et al., (2004) results from the rearing of laying hens caged indoors and with mesh floor, from which samples were collected for this research. These birds are fed a protein-rich foods, vitamins and minerals. In the process, many of these inputs are part of the chicken and this could explain the high content of nutrients found in mixtures 1 and 3. In the case of coffee pulp component of the mixtures Julca et al., (2008) have reported high values of MO (91%), P (0.28%) and K (2.5%). This high content of MO is an important source of nutrient release.

Tabla 7. Chemical parameters results for mixtures

PARAMETERS	UNIT	Mix1	Mix2	Mix3
O. M.	%	38,65 a	34,87 b	37,76 a
O. C.	%	21,84 a	19,07 b	21,32 a
Organic Nitrogen	%	1,88 a	1,64 b	1,84 a
Total Nitrogen	%	1,89 a	1,89 a	1,92 a
C/N ratio	%	11,5 a	10 b	11,1 a
C.E. C.	Meq/100g	27,24 b	27,44 b	30,58 a
Calcium	%Ca	1,19 a	0,47 b	0,379 c
Magnesium	% Mg	0,045 a	0,179 a	0,145 a
Potassium	% K	1,91 a	1,99 a	1,99 a
Sodium	mg Na/Kg	165	ND	ND
Iron	mg Fe/Kg	198 a	70,27 c	141 b
Zinc	mg Zn/Kg	ND	ND	ND
Manganese	mg Mn/Kg	288 a	202 b	310 a
Copper	mg Cu/Kg	0,895 c	1,39 b	1,76 a
Phosphrous	% P	4,84 c	8,04 a	7,18 b
Sulfur	% S	0,368 b	0,506 a	0,39 b
Boron	mg B/Kg	134 b	127 b	168 a

Different letters indicate significant differences P <0.05

The range of variation of the MO in the treatments ranged between 34.87 and 38.65%. The mixture 2, shows significantly lower values (P <0.05) in MO than other treatments. Mixtures 1 and 3 had the highest values of MO, this can be attributed to the fact that the manure possess a significant amount of bacterial flora and of N which are necessary for the decomposition of organic matter as indicated Paredes et al. (2000).

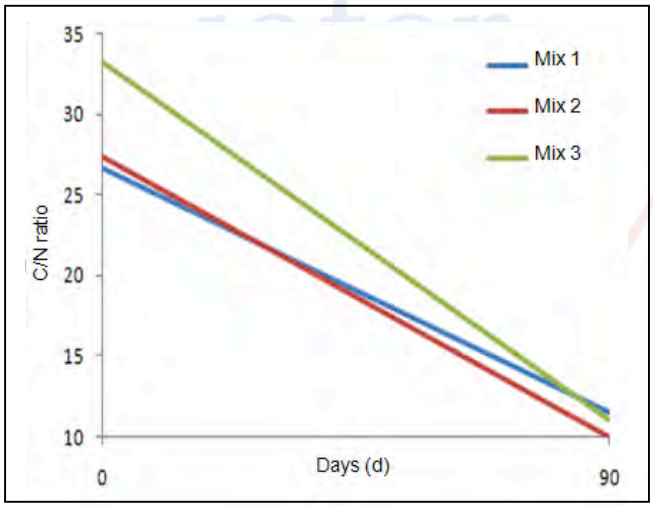
In a study by Pierre et al., (2009) where chemically and biologically evaluated compost coffee pulp mixed with goat manure, MO values was between 26.0 and 33.1%. In a compost quality, MO values are between 25 and 60% Barral et al., (2001), range within which the three treatments were the experiment. Similar results are reported by Duicela et al., (2002) who composted coffee pulp with different types of manure and vegetable waste, obtaining 25.7% of MO.

Melendez (2003) reported that the OM content in the mixture has a positive effect on soil fertility. It is shown that minimum increments of OM improve the physical, chemical and biological soil. Although it is possible that the different components are simultaneously affecting the MO and differently these properties.

With the results can not demonstrate a positive effect on soil fertility, but it can predict that the higher OM content in the mixtures, found higher nutrient content, which is related to the type of material used and the preparation of the mixtures. Castillo et al., (2000) indicate that in the case of composting, these exert a fertilizer in the soil and also contribute to improved physical and chemical soil.

The C/N, expressed in units of carbon nitrogen containing units of a material. A proper relationship between these two nutrients, promote good microbial growth and reproduction. Perez et al. (2006) mentioned that the C/N optimal for the start of composting mixtures is between 25-35/1, this ratio goes down to reach values close to 10-15/1 and when the material is ready for be used, the values previously reported in the treatments were evaluated (figure 3).

Figure 3. Initial and final values of the C / N ratio in the mixtures



It should be noted that carbon is used by microorganisms as a source of energy, while nitrogen is used for the synthesis of a substance and for the vital functions of the microorganisms. Calbrix et al., (2007) explain that when the C/N is greater than 40, the microorganisms take much time to break down waste for lack of nitrogen decreasing composting performance, if the C/N is low losses occur nitrogen in ammoniacal form due to significant temperature elevations.

The stability in composting refers to the level of activity of the microbial biomass and can be determined as mentioned by Conti et al., (1997), by the rate of O_2 consumption, CO2 production

rate, or heat released as a result microbial activity. For Wu et al., (2000) in the compost maturity refers to the degree of decomposition of phytotoxic organic substances produced during the active state of the process and can be assessed in different ways, Inbar et al., (1993) indicate that rates germination or compost extracts are a common biological method to evaluate the degree of maturity of the material and physical parameters of temperature, color, odor and chemical parameters such as C/N ratio, cation exchange capacity or rate of humification. The microbial criteria include: microbial counts, ATP content as mentioned by Garcia et al. (1992), microbial biomass or enzyme activity.

The finals values of the C/N for the three mixtures indicated that these were already in a state of maturation, as reported Illner et al., (2007) and Benito et al., (2003), the C/N with values close to 10 show a state of maturity of composted materials which would be ready for use as organic fertilizers. Additionally, De Carlo et al., (2001) mentioned that the C/N ratio, when this fenced-value to 12 allows the direct introduction of the product to the ground, as their level of maturity does not compete for N with seeds and plants. This is because the compost does not release organic acids, neither absorbs nor ammonia and N of the soil solution.

The CEC (cation exchange capacity) was significantly higher ($P < 0.05$) in the mixture 3, Benito et al., (2003) explain that CEC amounts as a function of humification due to the carboxyl formation and phenolics functional groups.

Macroelements: significant differences ($P < 0.05$) among treatments for N and P. K not show significantly different. The elements N, P and K values were within the proper range for the three treatments. Pierre et al., (2009) obtained values of N (4.4 - 5.9%) and K (2.5 - 3.6%) higher than found in this investigation, possibly because mixtures of this study contained high levels of manure without additional plant residues (like coffee leaves), the values of P (4.5-5.0) were similar in the two experiments.

According to Diaz et al., (1993), "soil microorganisms lead the biodegradation of organic matter and are an important reservoir of labile C, N and P". Swift (1997), also indicates that some microorganisms are able to establish mutual symbiosis with plants, such as growth-promoting rhizobacteria of the genus *Azospirillum* to fix atmospheric nitrogen in the endo of grasses, and others as arbuscular mycorrhizae that colonize plant roots.

Microelements: significant differences in the mixtures were detected, with the exception of Mn. The mixture 1 presented the highest values of trace elements, possibly because it is the mixture contains greater amount of hens manure, and as mentioned above this is a substrate rich in organic compounds and microbial.

After applying the paired samples t test to compare physico-chemical variables between composting field and microcomposting, found that of 19 variables, 14 were not significantly different (moisture, pH, C / N, S, N, NO, NT, MO , CO, K, Cu, Na, B and Zn), indicating that

may be extrapolated results in controlled environments to field conditions. Significant differences ($P < 0.05$) in the contents of P, Mg, Fe, Ca and CEC, possibly due to the heterogeneous nature of the contents in the substrates evaluated biochemical, microbiological dynamic and / or concomitant environmental conditions.

In this regard, Aikios et al., (2000) indicate that variations between micro and macro elements content within a study area may be due to microbial activity and dynamics with abiotic factors, allowing heterogeneity of biological populations and availability of minerals. Additionally Burbano (2002), mentions that the microorganisms break down organic substances into their basic components, water, carbon dioxide and minerals. In this sense, the activity of soil microbiota depends on factors that determine the conditions of this medium, as the structure and porosity, oxygen presence, temperature ranges, moisture and nutrient availability among others.

CONCLUSIONS

According to the organoleptic and chemical analysis, all treatments generated a mature compost, as they showed the standard conditions: dark, earthy smell and final C/N ratio between 10 and 15.

Mixtures 1 and 3 showed the highest contents of OM and OC, macroelements (N) and micronutrients (B, Ca, Fe, Mg, Mn and Na), the highest content of nutrients found in these mixtures is due in part to high presence of hens manure.

The mixtures met the internationally required values for the presence of pathogens of fecal origin, which is a quality to be considered for commercialization.

Comparing between microcomposting and composting fields, shows that in physico-chemical variables, 14 of those were not significantly different (moisture, pH, C / N, S, N, NO, NT, MO, CO, K, Cu, Na, B and Zn), which indicates that results could be extrapolated in controlled environments to field conditions.

The composting process time was less than reported in the literature (90 days) in this study were stabilized on treatment day 75, after which no changes in the dynamics generated bacteriological and physical-chemistry.

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Factors for Implementing Green Building Rating Tool to Government Building in Malaysia.

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Abstract:

Green Building Index (GBI) is the first green building rating system in Malaysia. It was introduced by professional body in 2009 instead of Government, to provide rating to private building in Malaysia. Nevertheless Malaysian Government is fully supports the GBI when in the budget 2010 government has given priority to turnover into more environment-friendly regardless of product or service. Government has also given incentive by giving tax relief to building owner that obtain the rating certificate from GBI. Some instructions have directed Public Work Department to use GBI in some construction project. Does GBI that driven by private organization and design to rate private projects is suitable to be implemented in government building project? The purpose of this paper is to find out what are the factors should be considered in order to implement green building rating tool to Malaysian government building. The survey was carried out in collaboration with building industry represent by Government building implementer, architects, engineers, educators, contractors and government central agency. Base on the result of the survey this paper has pointed out the factors or strategies of implementing the sustainable building rating tool.

Keyword: Green Building Rating Tool, Green Policy Development.

Introduction

Green building rating tool enhances the environmental awareness of building practices and provides fundamental direction for the building industry to move towards environmental protection and the achievement of sustainability(Ding 2008). Green building rating tool was developed to measure the improvement of the building environment quality related to basic needs. There are varies themes of green building rating tool all over the world. According to Maria Atkinson, Executive Director of Green Building Council of Australia (2003) these systems and tools can be used to support the sustainable design, since they transform the sustainable goal into specific performance objectives to evaluate the overall performance. There are different perspectives in different sustainable building rating and certification approaches, but they have certain points in common.

Green Building Index (GBI) was introduced in Malaysia in 2009 as Malaysia first green building rating tool. GBI was jointly developed by two professional bodies, the Malaysian Institute of Architect (PAM) and the Association of Consulting Engineers Malaysia (ACEM) as Greenbuildingindex Sdn. Bhd. Government of Malaysia is supporting the drive towards green building and Green Technology by announcing in Budget 2010 that contained: The fund of not less than RM 1.5 billion to be given as soft loans, Tax Exemption for building owners who obtain the New Green Building Index (GBI) certificate, buyers of buildings with GBI Certificates will also be exempted from stem duty (valid for sales executed between Oct. 2009 until Dec 31 2014).

The Ministry of Works has been directed to ensure that all new government buildings incorporate the features of Green Building Index (GBI) Malaysia as announced by the Minister of Energy, Green Technology and Water, Datuk Peter Chin on Tuesday.(Bernama 2009)

In connection with that, The Minister of Works, Datuk Shaziman Abu Mansor has announced that a Joint Council between GreenBuldingIndex Sdn. Bhd. and the government will be established in middle of year 2011 to coordinate green building management so that both private and government sectors will use the same green building rating tool(Koay 2010). An instruction was given to The Ministry of Works (PWD) to use GBI in a few construction projects. Among them is the ministry of works new building project (Kementerian Kerja Raya 2).

However, no study has been made to prove that GBI which was driven and designed for private projects is suitable to be implemented to government buildings. With some of the issues mentioned above, this paper will analyze the necessity of the government buildings to obtain certificate of green building rating tool. Based on the result of the survey, this paper has pointed the factors that should be considered in order to implement green building rating tool to government building in Malaysia based on the perspectives and experiences of the respondents.

Methodology

This research approach was qualitative in nature, using survey (through interview) to fulfill the above aims and objectives. According to Yin (2011) when references concerning the subject matter are limited, it is particularly useful to use qualitative inquiry. The survey was conducted

through a structured interview questions over four weeks period. This relatively short period was critical for the study.

Respondent

The interview was conducted with the Malaysia Building Construction Industry players, in particular the professionals (architect, engineers, designers) from Government Agency and private sector who involved with the Government Building Construction. All target respondents were very experienced in the building construction industry and most of them have more than 21 years of working experiences and in this context, most of them are directly involved in the development of sustainable building rating tool. Their roles in the Government Construction Project are varies such as Top Management Officer and Specialist Officer of Government Implementer Agency - Public Work Department (JKR), Value Management Officer of Government Central Agency - Economic Planning Unit (EPU), Research officer of Green Technology Corporation, President and Board Member of Malaysia Green Building Confederation (MGBC) and Board Member of Green Building Index Sdn. Bhd.(GBI).

Procedure

Researcher has approached all respondents through phone and by email to make appointment and informed them of the study and then distributed a copy of the structure interview questions to those who have an interest in this research. Those who agreed to participate in the study were then made arrangements for an interview.

A structure interview schedule was designed and used to obtain information about respondent experience and knowledge. Respondent was asked about constrains and potentials if government building to implement the sustainable rating tool. Interviews with the respondent were between 45 minutes and an hour long. Interview were taped and transcribed.

All transcripts were analyzed to get main themes and then coded according to those themes using the three phase coding system. During the first phase of coding, researcher performed an initial scan of the data, highlighting words or phrases used by the participants and locating initial themes. Researcher identified the core phase, focused on connecting themes and finding links in the data. In the final phase, researcher reread the data and illustrates the final themes. All coding was rechecked to ensure it was coded accurately as shown in Table 1.

Result

The analysis of interviews with Malaysia Building Construction Industry players from Government Agency and Private sector revealed twenty five themes in order to implement green building rating tool to government buildings in Malaysia as shown in table 2.

Respondent	Themes
Respondent 1	Performance , promotion and awareness, educate, financial, role and responsibility, implementation,
Respondent 2	Maintenance, impact
Respondent 3	Priorities of energy efficiency, location,
Respondent 4	promotion and awareness, cost, value management, educate the professional, roles of consultants, procedure of contract, policy, objective to achieve, enforcement, target area, easy to calculate , easy to achieve, specific scope, optimize the resources,
Respondent 5	Promotion to stakeholders, training our people, adapt green element in the office, manage the data, be references, be apprentices.
Respondent 6	Location, design, operational method,
Respondent 7	Location
Respondent 8	Performance, procurement, control by government, regulation, protect public interest, maintenance, impact, easy to measure, method, target of operation, monitoring.

Table 1 : The Themes of factors that are highlighted by respondents.

Factors / Respondent	1 Promotion &	2 Educate	3 Roles &	4 Adapt green	5 Manage data	6 References	7 Apprentices	8 Performance	9 Impact	10 Priorities	11 Value	12 Easy To	13 Scope	14 Optimize the	15 Objective to	16 Protect public	17 Financial/ Cost	18 Monitoring	19 Maintenance	20 Location	21 Procedure of	22 Policy	23 Design	24 Operational	25 Regulation
Respondent 1	√	√	√					√									√								
Respondent 2									√										√						
Respondent 3										√										√					
Respondent 4	√	√	√								√				√	√	√				√	√			
Respondent 5	√	√		√	√	√	√																		
Respondent 6																				√			√	√	
Respondent 7																				√					
Respondent 8								√	√			√				√		√	√		√				√

Table 2 : The themes are divided according to phases.

Result of the study shows that there are twenty five factors to be considered in order to implement the green rating tool to government buildings in Malaysia.

Preparation of people involved

Seven out of twenty five themes of factors to be considered are related to people who are involved in government building projects. The factors are promotion and awareness, educate & training, adapt green element, roles & responsibilities, be apprentices and be reference.

Three out of eight respondents described that promotion and awareness should be considered in order to implement the green rating tool to government buildings in Malaysia.

> "Promotion to our stakeholders including client and contractor; we should promote to them so that once they understand, it will be easy to implement." – (Respondent No 5)
> "I believe that the combination of a few factors such as how the end users use the buildings and the simple design of these buildings must lead towards that. The consultant must be aware of that including the financial part. It is the awareness of helping the environment."- (Respondent No 1)
> "I think it should be awareness to the user especially the stakeholder."- (Respondent No 4)

In relation with awareness, education was highlighted by three respondents as one of the important factors to be considered in order to implement the green rating tool to government buildings in Malaysia.

> "The factors are very simple. They are the building owner; in this case it's the government and the end users. The end users are very important and they need to be educated. Even if the buildings are with beautiful skin, they still live with the air-conditional on."- (Respondent No 1)
> "Basically it should be awareness and of course the professionals have to be educated. What I mean is if we are talking about JKR, we should educate our technical people more than our consultants. All should be aware and play their roles."- (Respondent No 4)
> "We have to focus on training and promotion. Train our people so that they are more aware of green building"- (Respondent No 5)

Similarly, two out of eight respondents talked about roles and responsibility as one of the factors to be considered in order to implement the green rating tool to government buildings in Malaysia.

Respondent no 5 also described about adapting green element in the office.

> "We have to enforce it by adapting green element in the office first, even if it is just a small initiative. At least we have to apply the green element, especially for designers and project implementer" - (Respondent No 5)

Respondent no. 5 also highlighted that to be references, manage the data and be apprentice as the factors to be considered.

> "Another one is, we have to be a reference centre and we have to have data or information. How are we going to do it if we don't have any data? We must have the data and manage the data properly and easy to be accessed by others."
> "We must also have apprentice because in term of rating, green building is something new for us. Our people still cannot accept it yet, so we have to do it progressively. People who don't understand will look at it negatively. We have to learn together."

Green rating tool criteria

Nine out of twenty five factors are related to rating tool criteria. They are performance, impact, priorities, value management, objective to achieve, scope and easy to measure.

Two respondents highlighted that the performance of the building was the most important factor to be considered in order to implement the green rating tool to government building in Malaysia.

> "We look at the performance of the building, not the owner."-Respondent No 1.
> "The factor that affects the real performance of a building at this moment is referring to carbon."- Respondent No.8.

Respondent No 2, No 6 and No 8 have described that the impact of the rating tool was one of the factors to be considered.

> "Social impact of the projects is difficult to measure. The tool has not been clearly established yet. I think something need to be addressed well when you develop this, such as how are these projects going to help the surrounding people"- Respondent no 2.
> "You need to look at what sort of impact your operation has on the environment and you have to work your way to mitigate them."- Respondent No 6.
> "By doing the rating, it is not just to reduce carbon but will indirectly give impact on the energy efficiency of a building."– Respondent No. 8.

Meanwhile, respondent no 3 has highlighted that priorities in the rating tool was one of the factors to be considered in order to implement the green rating tool to government building in Malaysia.

> "Energy efficiency should be the first priority if we want to give green rating to our building"

Respondent no 4 has described that four factors such as easiness, optimization, value management and scope that are related to the green rating tool in order to implement it to government building in Malaysia.

> "The tool should be easy for them to use to calculate by their own selves. It means, it will be easier for them to achieve the green rating."

"Our objective is an optimization of a resource where we have to look at all angles. It means how much we are going to spend from the capital in order to achieve certain level of sustainability."
"Now we go for value management. We will look into how we are going to optimize our resources by looking at life circle cost and scope."
"At the end of it we want to achieve carbon reduction for buildings but I think the scope must be more specific."

Similarly, respondent no 8 has mentioned that easy-to-measure tool was one of the factors to be considered.

"I told Putrajaya Holding that it's good that we go for energy efficient building. We have the LEO building because it is easy to measure the level of its energy efficiency. I think LEO concept is accepted by EPU. Every month we can measure and show them the progress".

Implementation

The result of the interview shows that nine out of twenty five factors to be considered are during implementation stage. They are finance/cost, location, procedure of contract, policy, regulation, design, operational method, monitoring and maintenance.

Respondent no 1 and no.4 have mentioned that finance or cost was one of the factors to be considered in order to implement it to government building in Malaysia.

"The other factor that I mentioned earlier is the financial part. So far, the figure obtained is consistent with international example that is the cost of going green is in single digit and in some cases it is close to zero. This is because the cost of the base building is already high in implementation of MS.1525 2007."- Respondent no.1.
"There is a complaint says it's difficult to get funding to do all these green initiatives,… we are also looking at life cycle costing. Even from the initial capital cost, it is a little bit higher but in a long term we will save a lot, so we will consider it". – Respondent no. 4.

Three out of eight respondents highlighted that location was one of the factors to be considered.

"For me, location is very important if we want to rate the building. For example, our buildings here are beautiful but with limited parking spaces and poor public transportation at the area, people who work here always have to chase for the parking spaces". – Respondent no. 3.
"Then you need to look at factors such as related to the site that means where we place the building, the orientation and the passive design". - Respondent no 6.
"I think location is a factor. What is the difference between government buildings in Kota Bahru, Putrajaya and Sarawak? It is the availability of fund for that transformation". - Respondent no. 7.

Respondent no.4 has mentioned that procedure and policy should be the considered factors in order to implement it to government building in Malaysia.

> "In contract, maybe in term of procedure, policy was a form of encouragement by the government. But so far there is no stronger policy other than tax exemption. In actual practice there are a lot of obstructions."

Same goes with the opinion from respondent no 8 that described about policy and regulation and protecting public interest.

> "Government gave tax exemption to the building with GBI certificate. For government building it's depending on the procurement and incentive. It's more to motivate…. The industry also asks why it is just GBI? For me, whatever the development is, it should be controlled by the government because now nobody regulates Green Building in Malaysia. I think this is the time to protect public interest in Malaysia."

However respondent no 6 has mentioned that design and operational method should be considered in order to implement it to government building in Malaysia.

> "The orientation of the building, the passive design and the M&E design would be based on how you intend to operate the building and what your aspiration is"

Respondent no 8 has described that maintenance and monitoring should be considered as one of the important factors in implementing the rating tool to government building.

> "Actually the system is there, but it is not well-maintained. There are energy wasted and no monitoring done. They just monitor the performance of plan but in term of energy, it is just the same, no saving. So what's the point? It is only to get the certificate."

Similar with the opinion of respondent no 2 that maintenance should be considered as one of the factors.

> "Sustainability can be maintained by a preventive measure or preventive maintenance. For example, by installing a metal plate to a janitor room door, the door won't break even if you keep banging on the door at least for one or two years. The metal plate is a preventive measure."

Discussion

The finding shows that all twenty six factors can be divided into 3 phases. The phases are preparation of people involved phase, criteria of green building rating tool phase and implementation phase.

The first phase is preparation of people involved in the government projects. The people involved are stakeholders, users, designers, consultants, contractors, those in facilities management and the public. The factors are promotion and awareness, educate & training, adapt green element, roles & responsibilities, be apprentices and be reference. In this phase, the people involved either directly or indirectly with government projects should have the knowledge on

green building. Promotions and awareness campaigns should be done more frequently all over the country. Besides, the government should give more training and education to all levels of government officers or at least adapting the green element in the office. By giving the knowledge on green building to people involved in the government projects, they will know their roles and responsibilities and get prepared to become apprentices and reference to others.

The second phase is criteria of green building rating tool that is going to be implemented to government buildings. In this phase, the related tools should have factors such as performance, impact, priorities, value management, objective to be achieved, scope and easy to measure.

Finally is the implementation phase. Nine out of twenty five factors to be considered during this phase are finance/cost, location, procedure of contract, policy, regulation, design, operation method, monitoring and maintenance. These factors should be considered in order to implement the green rating tool to government building in Malaysia.

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Using GIS to Manage and Assess Urban Risks. A Review Comparing the Experiences of Romania (In a European Context) and The United States of America

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Abstract:

The paper summarizes the evolution of GIS, with a particular focus on its use in mapping, assessing and managing urban risks. In this particular setting, the emphasis is set on using GIS as a decision support system instead of being regarded as simply some "other" mapping software. The characteristic underlines its analytic capability, based on combining data base functions with spatial relationships, allowing for relating objects belonging to different layers using their spatial attributes. Examples from the United States of America and Romania, organized based on the four phases of disaster management – mitigation, preparedness, response and recovery – are discussed; overall, they suggest that Romania is in its early stages of using GIS to manage urban risks and as a planning tool in general. This happens mainly because detailed digital data on what might be affected is unavailable to be used with a GIS. Nevertheless, the Romanian situation is likely to improve as an effect of adapting to the European requirements, as suggested by existing trends.

1. Introduction

Even though a computer-based GIS, could not appear before the computer, its functioning was possible without it. Therefore, some authors argue that the first GIS were the map of the 1781 Yorktown battle, the 1819 map of illiteracy in France made by Pierre Charles Dupin (Iosub, 2008) or the 1854 map illustrating the connection between the source of contamination and addresses were cholera cases were recorded during the outbreak in London, produced by Dr. John Snow (Gordis, 1996). Especially the latest one is a GIS in its true sense, as is integrates two layers of information – utility (water supply) and medical (cholera) data, linking them into an attempt to identify the cause and act accordingly.

Modern GIS appeared in 1969 in Canada and was the work Roger F. Tomlinson, who concluded the implementation of Waldo Tobler's principle '*Map In, Map Out*' (MIMO), started in 1959, and resulting into the digitization of all paper-based maps (Iosub, 2008). In the United States, digitized maps were the start point updated continuously and used as a support for integrating other data. ESRI launched its first product in 1981 (Letham, 2007) with ArcView. The development of GIS is marked by true revolutions; unlike other software, users were involved in its development by creating extensions. The process resulted in the emergence in ArcGIS 8 of a new concept, '*interoperability*', consisting of many features: compatibility with other products and applications, possibility of being used in a network where users can modify data (documenting any changes), and delivery of final products (ESRI, 2003a).

The first feature reached its apogee by creating GIS models importing and exporting data to other applications during the processing flow, performing the format changes automatically (ESRI, 2003a). The second feature relies on the concept of '*metadata*', meaning 'data on the data': file format, creation and change time, geographical projection and other information useful for tracking any changes. The third feature consists of shifting from products that could be delivered only to users who needed the software to visualize them up to creating self-standing applications and finally via the Internet (ESRI, 2003b), *e.g.*, the Yahoo maps, that allowed the United States people to obtain driving directions in both map and text format by simply entering the start point and final destination.

2. Using GIS to manage urban risks: American and Romanian examples

Fig. 1. Bucharest buildings at highest earthquake risk (above) are marked with a 'red dot' (indicated by the yellow arrow) reading 'building assigned to class I earthquake risk (highest) according to the technical expertise'

There are four phases in disaster management, namely mitigation, preparedness, response and recovery; GIS can be used in all of them. They correspond to actions taken long time before, shortly

before, shortly after and later after the occurrence of a disaster, consisting of better planning (to mitigate), alert systems (for preparedness), rescue and clean-up (in response) and reconstruction, including mitigation of future events (during the recovery) (Erlingsson, 2005).

For example, when discussing about the earthquake risks, the mitigation consists of identifying the buildings at risk (Georgescu, 2010). In Bucharest, Romania they are already known as the 'red dot' buildings (**Fig. 1**, top), since they are marked with a red circular banner reading 'building assigned to class I earthquake risk (highest) according to the technical expertise' (**Fig. 1**, bottom). GIS can be used to first map their exact location, and in later stages to plan the actions to be taken in the next steps: evacuation routes, emergency assistance and clean-up, based on the correlation with the road infrastructure, and the reconstruction, based on urban planning regulations.

Preparedness consists of designing programs for the fast evacuation of buildings at risk, previously identified. The evacuation routes and patterns may be designed efficiently based on an in-depth knowledge of the road system. Unfortunately, such maps are not available for Bucharest, and even if some routes exist in digital format, they are not updated and associated databases do not contain essential data, such as the estimated driving times.

The management of rescue operations is based on the same principles. Spatial analyses of cost effectiveness can easily be carried out, but require exactly the data lacking in Bucharest. As a general idea, to estimate the arrival time one could start from a straight line if road information is unavailable; once data is available, the real route increases. If additional data reflects the type of road (e.g., one-way streets can extend the route), the results become even more exact. For all this steps, the average speed limit can be used (50 km/h in urban areas). However, knowing the exact traffic flows increases the precision of the estimations and increases the effectiveness of planned interventions.

The eventual reconstruction should take into account all experience and progress made in planning. Most of the 'red dot' buildings were built before the major 1977 earthquake. Construction and urban planning learnt from its experience, and while little can be done for the existing buildings, in the event of an earthquake the new constructions could benefit from the lessons learnt in 1977.

Last but not least, a '3-D' model of a city works better than a classical two-dimensional one. Nevertheless, there are huge costs associated to it. In order to produce the noise map of Bucharest, the 3-D digital model of Bucharest, produced by a private company, was used. However, its price is around 100,000 euros; a similar model was made for Paris and the cost was 1,000,000 euros. Updating it is also expensive. The utility of a 3-D model is hard to estimate; one of the most reputed American specialists in remote sensing, Dr. John Jensen at the University of South Carolina, usually relates in his class the anecdotic situation when he was approached by a student who asked him for advising a doctoral dissertation focused on the analysis of digital information in order to maximize the impact of a nuclear bomb thrown against a given city; while Dr. Jensen, trying to hide the shock, asked him to find a different advisor, the problem can be reverted in an attempt to identify the tools for minimizing the adverse effects of an eventual disaster against a city.

2.1. The United States experience

America has an extensive use of GIS, since the first GIS appeared in the United States in 1969. At the same time, America has a long experience in facing disasters, from California earthquakes to wood fires, terrorist attacks, tornadoes and hurricanes, ice or snow storms and many others (Greene, 2000, 2002), regardless of the size of the area affected.

The first question to be asked in assessing the vulnerability is 'What is going to be affected' (Greene, 2002). Of course, land cover describes the physical coverage and land use, how the human

communities do actually use the land (Jensen, 2000), but this is the simplest answer. More elaborated (and useful) answers assign value to the elements potentially at risk.

2.1.1. Planning ahead

While GIS needed a long time to be perceived as a management tool rather than a realm of specialists, facilitated by the '*digital revolution*', especially the interoperability and particularly the delivery of outputs via the Internet, the understanding also required considering the question of '*where*' in addition to '*how*', '*why*' and '*what is the cost*'. Fortunately, the change occurred at the same time with the expansion of GIS capabilities and availability of other tools, such as advanced remote sensing instruments or the Global Positioning Systems (GPS). In the United States in particular, the management-based use of GIS was facilitated by a democratic system, for which information is its lifeblood (Greene, 2000).

One of the examples is the CATS software, designed by Science Applications International Corporation, an ESRI partner. Initially designed to better prepare for nuclear disasters, it can also be used for natural adverse events, such as earthquakes, for environmental issues such as oil spills or discharged pollutants, or for terrorist attacks. The software allows for estimating the number of deaths and injuries and the amount of supplies needed, modeling the path of a hurricane and outer areas suffering from storms and floods, identifying vulnerable population. Its operation relies on street maps, and GIS-based locations of airports, hospitals, railroad bridges, dams, cemeteries, power and nuclear plants and refineries. The estimations are very realistic; 674 homes were predicted to suffer from 1993 hurricane Emily and 683 were affected; 560,000 applications for help were expected with the 1994 Northridge earthquake and 570,000 were received; and 5,100 applications for help were received from the Virgin Islands due to 1995 hurricane Marilyn compared to 5,300 expected (Greene, 2000).

A similar example, probably equally known, is HAZUS, resulted from the Federal Emergency Management Agency (FEMA) to help communities plan and prepare for disasters by offering a free tool. The package is used mainly for modeling based on rigorous national standards. Started as a product focused on earthquakes, it increased its capability to include flood and wind modeling, up to the entire spectrum of adverse events. In the first case, the models required the input of an epicenter, chosen arbitrarily or based on historical data to compute a wide spectrum of damages, as well as probably recovery needs and costs, including human casualties, direct economic losses, shelter needs, structural damage, essential facilities (airports, schools, hospitals and utilities), extent of fires and amount of debris resulted, as well as the indirect economic losses. In addition to these, social and cultural parameters were included (Greene, 2002).

2.1.2. Mitigation

The use of GIS at this stage allows for precisely locating the hazards, and through its visualization capabilities communicates what needs to be done. At the same time, GIS allows for knowing the precise location of the valuable elements, which need to be protected firstly (Greene, 2002).

One of the examples is provided by the activity of firefighters. While fires may have other causes, they represent a negative consequence of many disasters, such as earthquakes. Tim Walsh, the Fire Captain GIS specialist of Marin County, has developed an entire system in this regard, based on four analyses. The most complicated is 'Level of Service', using an economic damage assessment map to compute the probability of a fire resulting into unacceptable losses, including its extinguishment. The model includes the map of vegetation, classified based on its fuel ranking (Greene, 2002).

2.1.3. Preparedness

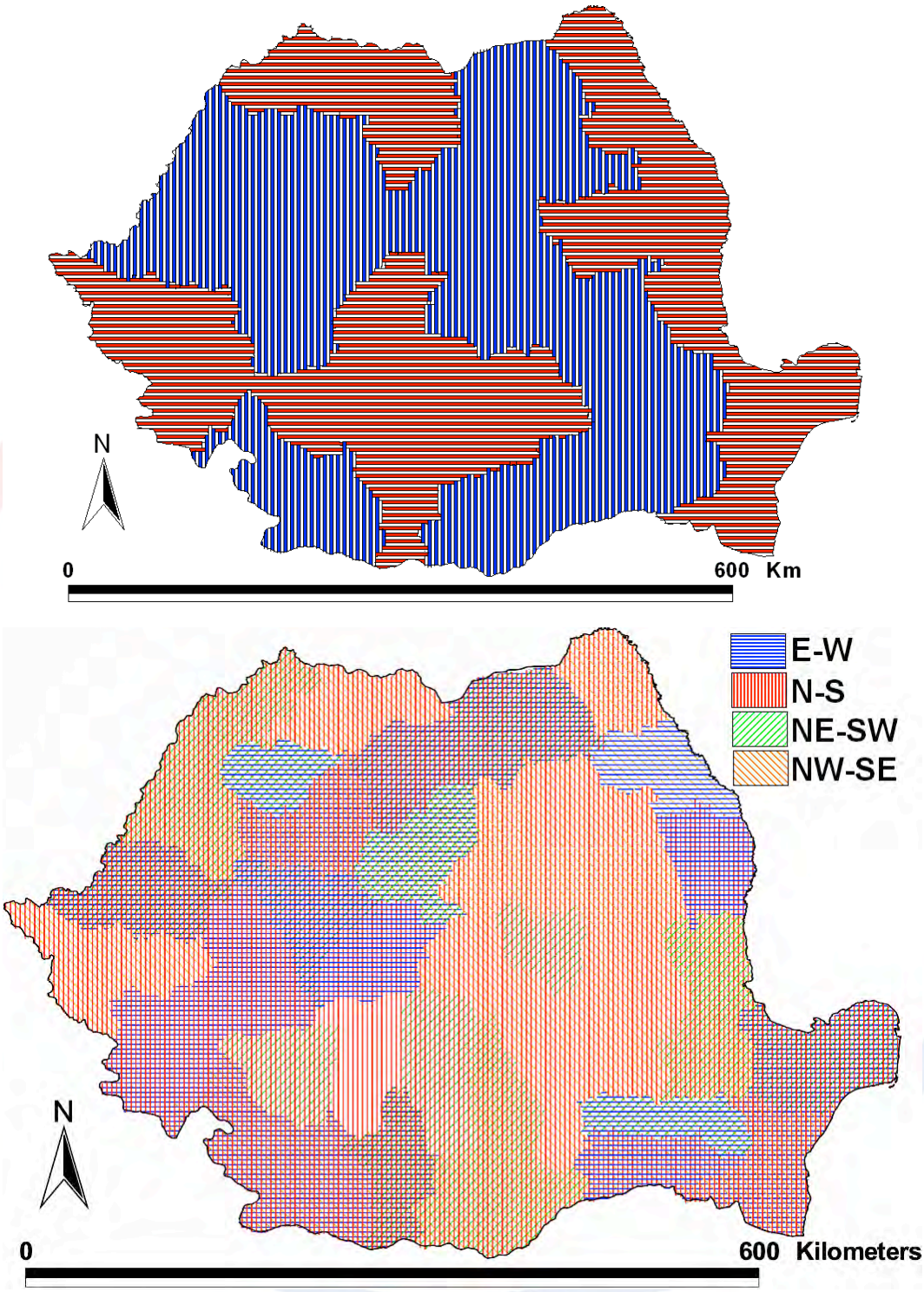


Fig. 2. A possible approach to assessing accessibility based on the orientation of main communication routes in Romania. In both cases, the lines forming a hatch correspond to the actual orientation of routes. The image above displays all roads with the same orientation (N-S or E-W), summed by total length per county; the one below displays the density of all roads and railroads of the same orientation (N-S, E-W, NE-SW and NW-SE) summed again by county

As it has been shown before, the road infrastructure plays a key role in preparedness, but also in the other stages. This chapter will present two macro-scale analyses, which can easily be applied to the micro-scale too. The first analysis looks at the accessibility of Romanian regions starting from the orientation of roads, based on the angled formed by each segment with the North axis. The simplest

method is to classify orientation binary, as 'North-South' or 'East-West'; the approach is also likely to reduce the errors (Petrişor, 2010). The next level is a four-level classification. Following the classification of orientation, the total length of segments with the same orientation is summed by spatial units.

The method is useful in comparing the accessibility of different units, administrative or geographic. The results at the national scale, based on a binary classification, indicated that long distance communication is interrupted on any of the two directions by the relief, resulting into low regional accessibility and isolation (**Fig. 2**, above); at the same time, it differentiated the regions that are connected on more or even all directions from those connected on a single one, therefore isolated (**Fig. 2**, below). At the level of a city, the method can suggest the best evacuation routes in case of a disaster, and pinpoint the isolated areas, that require particular attention for this reason.

A more sophisticate methodology is presented by Ghiţuleasa et al. (2011). The method can be used to compare two routes – in case of a disaster, evacuation routes – based on two parameters. The first one looks at their path; the optimal one minimizes, by analogy with the least square methods, the sum of squared distances computed using a N-S line drawn from the center of each accessible city to the path. A city is considered accessible based on the 45 minutes isochrone (Nordic Centre for Spatial Development, 2005; Spiekermann & Wegener Urban and Regional Research, 2007), i.e., it can be reached within 45 minutes. The time can be converted to distance using an average speed (in the study, 65 km/h; for urban areas, 50 km/h).

The second indicator is called "*potential accessibility*" and consists of summing up the population of accessible cities, defined again based on the 45 minutes isochrone. Again, the study transformed the time in distance based on the average speed. Each or both indicators can be used to compare the efficiency of routes.

2.1.4. Response

One of the very first outputs of a GIS coming to everyone's mind is the map. Maps are usually accessible to any user, and media tends to promote them, as any other graphic display of information, including the description of disasters. For this reason, they became even more popular than they used to be. As mentioned before, nowadays maps can be delivered directly by a GIS system via the Internet. Pierce County (Washington, DC) created a complete Internet Emergency System, built as a Web site for the Emergency Operations Center. The system embeds the location of emergency telephone calls. In addition, once cases are stored, GIS can be used to analyze their spatial distribution. A similar system is used in Mecklenburg County, NC; its capabilities were expanded to include the possibility of ordering evacuation or alert them to dangerous conditions. In Pennsylvania, agencies with potential lead disaster response attributions joined their efforts to produce a state-level Incident Response System, available also on-line (Greene, 2002).

2.1.5. Recovery

The 1994 Northridge Earthquake in Southern California proved once again the usefulness of GIS. The first outputs were maps detailing damage locations; the novelty consisted of using damage models to extrapolate from the field, direct observations and 911 calls. The maps displayed the intensity (perceived based on physical damage and sensations), using the Mercalli scale. Based on overlaying ZIP codes over the locations, people who suffered intensities over level VIII were almost instantly given temporary housing funds (Greene, 2002).

2.1.6. Mapping the earthquakes

One of the most notable state projects in seismic digital mapping projects is a result of the 1990 California Seismic Hazards Mapping Act, requiring the mapping of seismic hazard zones and identification of risk areas subject to potential ground failure, in order to help cities build their

regulations on development. The maps show areas where historic amplified ground shaking has occurred or local geological and geotechnical conditions indicate a potential for ground shaking to be amplified to a level demanding for mitigation, areas of past or potential ground displacements and past or potential landslides induced by earthquakes. Mapping is a priority in urbanized areas; by 2000, most parts of Alameda, Los Angeles, Orange, San Francisco, Santa Clara, and Ventura counties were mapped at a 1:24,000 scale (ESRI, 2000).

At the federal level, the United States Geological Survey produced the National Seismic Hazard Maps, available on the Internet since 1996. FEMA's predictions increased the efficiency of speeding relief to victims of natural disasters. After the Northridge earthquake in northern California on January 17, 1994, FEMA predicted using the GIS that 560,000 households would be affected, and received about 600,000 help applications. A noteworthy local or regional organization in the area of seismic hazard mapping is the Association of Bay Area Government. Assisted by the USGS and the National Science Foundation, the Association has been using GIS technology since 1975 to map seismic hazards for in its area (ESRI, 2000).

2.2. Earthquake mapping and GIS use in Romania

2.2.1. Legislation and strategies

There are several legal requirements connecting one of the functions of GIS – mapping – to the management of disasters. As a general framework, the 'Strategy for preventing emergencies' provides, with respect to natural disasters, for increased preparedness by identifying and mapping areas potentially exposed, elaborating risk maps, and establishing spatial planning policies in accordance with these maps, as well as insurance policies based on such data (Rechiţean, 2009). Nevertheless, in 2008 only 5 of the 41 Inspectorates for Emergency Situations in Romania had a map displaying the precise location and addresses of buildings (Sandu, 2008). Bihor County was among the first to implement a GIS system for emergency situations, using data on streets and buildings in addition to city maps.

In addition, many spatial and urban planning regulations, such as the normative acts subsequent to the Law on Authorizing Construction Works, require plans in a GIS format. While compliance with these requirements is not necessarily a problem, their implementation was not easy, as GIS was often used as a mapping or even drawing system, similar to Corel or Autocad, disregarding its ability to integrate layers of information. Despite of the difficulties in implementation, such requirements have been embedded in a national program focused on producing cadastral databases for buildings, utilities and other components essential to urban and spatial planning (Petrescu *et al*., 2005).

The European Union legislation and requirements shape out the future of mapping hazards in Romania (European Commission, 2010a, b). While in general terms the European Union recommends an integrated approach based on a common and shared appreciation in a crisis situation linking threat and risk assessments to decision making (European Commission, 2010a), specific provisions encourage the inclusion of social, economic and environmental variables into GIS models used to map expected spatial distributions of major hazards (in separate maps), all relevant elements that need to be protected (population, infrastructures, naturally protected areas etc.), and vulnerability in terms of susceptibility to damage for all relevant subjects of protect; in a second phase, new maps should display the combination of likelihood and impact of a certain event as well as for aggregated hazard maps (European Commission, 2010b). Nevertheless, the second document refers in particular to flood mapping only.

These new requirements are at the core of future Romanian initiatives taken by the National Institute for Research and Development in Constructions, Urbanism and Sustainable Spatial Development URBAN-INCERC. One of them is the preparation of a reaction paper addressing the

EU Strategy (European Commission, 2010a), amending it with the mapping of earthquakes, of particular importance given the seismic status of Romania. A second one continues it proposing a study titled "*Evaluation and map of seismic risks in Romania for the national management of disasters in line with the European Union Internal Security Strategy*" to be carried out by the same institute in partnership with the Institute of Geography at the Romanian Academy.

2.2.2. Earthquake mapping

Since several institutions deal with earthquakes in Romania, maps were produced as a requirement by law. The usual seismic hazard data were zoning maps (Georgescu, 2006), most of them covering the entire territory. Urban scale maps were developed only for some major earthquakes, based on the extrapolation of the values recorded in the stations composing the National Seismic Network.

Fig. 3 illustrates the mapping process at the national scale (top and middle maps) and for Bucharest. The middle and bottom maps were produced by the National Center for the Reduction of Seismic Risk at the National Research Institute INCERC after the 2004 earthquake, while the top one is a general map.

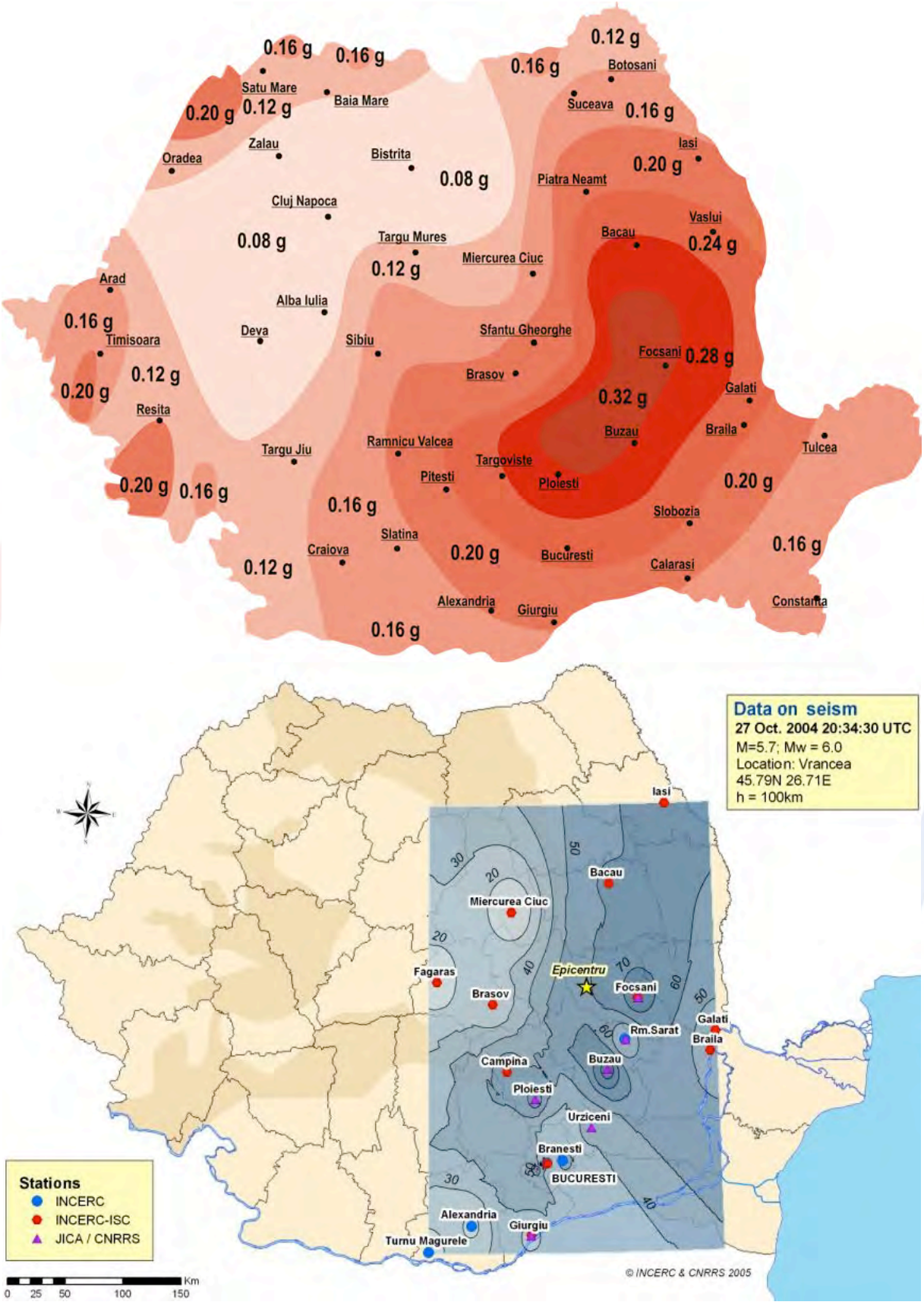
Apart from the scale issue, the implementation of GIS technology in mitigation, preparation, response and recovery related to urban disasters, particularly earthquakes requires large amount of data. As it has been shown previously, there is a need to know what is at risk. The inventory of 'red dot' buildings is currently a list; the list must become a geo-referenced database, with the exact location of each map. Data on the occupants would be a plus. Since these buildings are at high risk, preparation and response would be facilitated if the major road infrastructure related to these buildings is known. Finally, more detailed analyses, including cost assessments, required additional information stored in the table of attributes.

2.2.3. Use of GIS technology in Romania

Romanian GIS users are growing accustomed to its benefits, while even many Romanian researchers consider the geospatial technology to be novel and edge-cutting, despite of the first product appearing in 1969. For many people, a GIS is just 'another' mapping product, perhaps not as easy to use and very few reached to the level of using it as a research or analytical instruments. Nevertheless, managers were able to immediately see its benefits. The Chief Architect of Satu Mare County is one of the pioneers, who realized the potential of GIS in being used as a planning instrument. After years of digitizing available information, which is updated permanently, building permits are automatically issued using GIS to check whether a proposal meets all the economic, juridical and technical zoning requirements (Gheorghiu, 2007). The platform is in place to embed other pieces of information.

A resembling situation is found in Oradea, were the benefits of using GIS for urban management and control purposes were obvious for the Chief Architect of the city (Luncan *et al*., 2010) and the commune Floreşti in Cluj County, where GIS has become a part of the information system used by the City Hall in the decision making process (Haidu *et al*., 2006).

On a similar note, different research projects developed research projects involving the use of GIS technology to map historical monuments in Tulcea County (Bica *et al*., 2008; Topoleanu *et al*., 2009; Popescu, 2011), identify and characterize hardly accessible mountain area exhibiting a high potential for tourism in order to include them in circuits (Popescu and Petrişor, 2010).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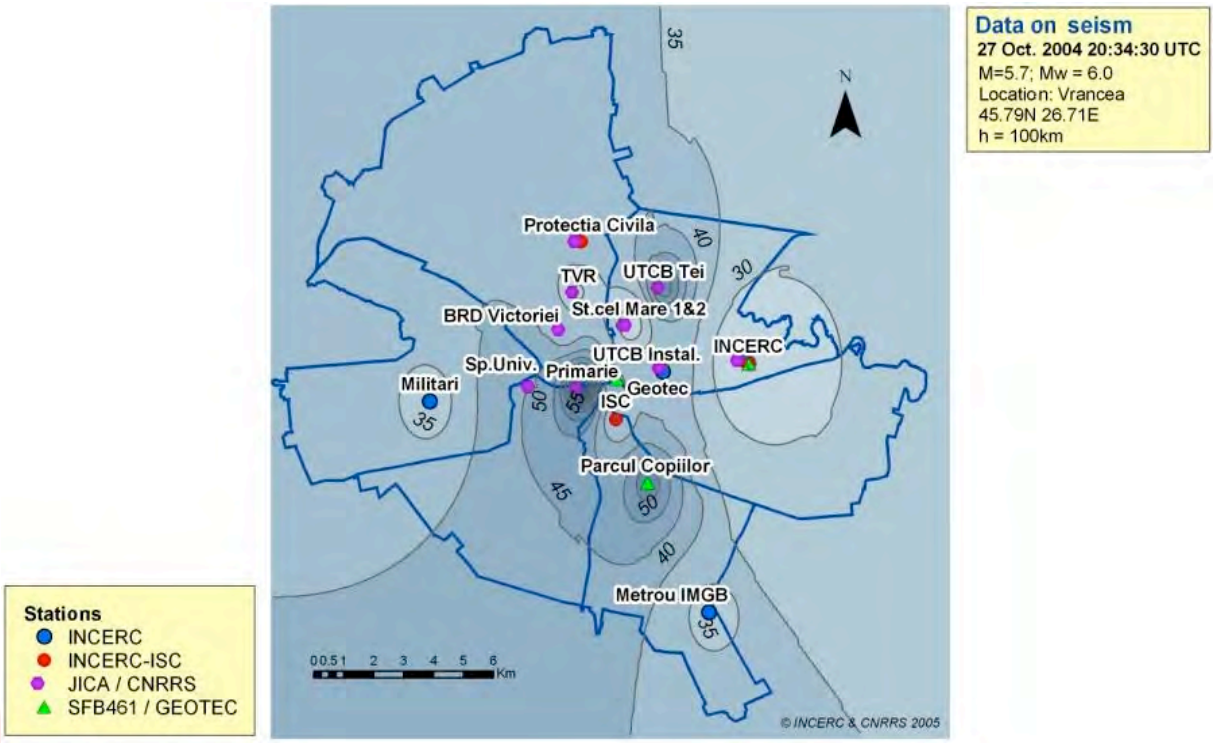

Fig. 3. Seismic maps in Romania. Top: peak values of terrain acceleration *ag* for earthquakes reoccurring every 100 years; middle: maximum terrain acceleration at the October 27, 2004 earthquake (cm/s^2) in Romania; bottom: maximum terrain acceleration at the October 27, 2004 earthquake (cm/s^2) in Bucharest

In terms of uses directed to the assessment of specific urban risks in Romania, GIS was used in conjunction with data mining methods to assess seismic vulnerability (Leon and Atanasiu, 2006), managing seismic risk (Atanasiu and Leon, 2007) or visualizing the spatial distribution of infrastructural risk (Toma, 2010) in Iaşi. In the National Park Călimani, an in-depth study linked GIS-based risk assessment to private insurance; however, the research was mainly focused on technological risks (Mara and Vlad, 2009). A research grant was focused on the assessment of seismic risk at the national level, embedding GIS in a software platform to pinpoint critical zones vulnerable to seismic events (INCERC Bucharest, 2006; Craifaleanu *et al*., 2008).

3. Conclusions

If GIS are seen as decisional or management instruments (this particular viewpoint appears to be shared by urban managers) their usefulness in saving lives and reducing costs cannot be denied. All the examples presented point to the need of utilizing GIS to solve specific urban issues. Nevertheless, the computer, software, methods and qualified users cannot do too much without permanently updated and reliable data. The latest constitute the main challenge for managing specific urban risks in Bucharest. In this regard, an overview of the Romanian experience shows that relevant research covers only large cities or even territories. For this reason, much can be learned from the American experience, as there are good premises for developing GIS-based platforms to save lives and money.

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Building a Social Case for Business Sustainability

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The Asian Conference on Sustainability, Energy and the Environment

Official Conference Proceedings 2012

Abstract:

Within the sustainability literature the concept of the business case for sustainability is well established. The intended meaning of the business case is that the pursuit of sustainability as a business objective will increase an organisation's economic performance; if it does not then there are no financial reasons to pursue sustainability.
However, a weakness of this approach is it is restricted to an examination of financial performance within the economic dimension of sustainability; whereas sustainability is very much a multidimensional objective including social and environmental elements. This paper begins with a review of the literature pertaining to the business case for sustainability, followed by a critique of the one dimensional nature of this concept.
This leads to the development of a model to assess the broader social case' for sustainability using Storberg-Walker's Five Components of Conceptu

Reviewing the business case

Reference to the business case within the sustainability literature typically carries the intended meaning that the pursuit of sustainability as a business objective is expected to increase an organisation's economic performance (Epstein & Roy 2003; Dyllick & Hockerts 2002). The implicit assumption is the business focus on profitability and other key measures of financial performance are the relevant criteria with which to evaluate sustainability projects.

The potential business case for sustainability needs to be examined on a case by case basis, as the link between sustainability and economic performance could be positive or negative; and there is data showing evidence of both (Salzmann *et al.,* 2005, p.29). Schaltegger (2010) contrasts negative business case sustainability projects which represent an additional cost thereby reducing profitability, with positive business case projects that reduce environmental costs and impacts, and thereby improve both environmental and economic performance.

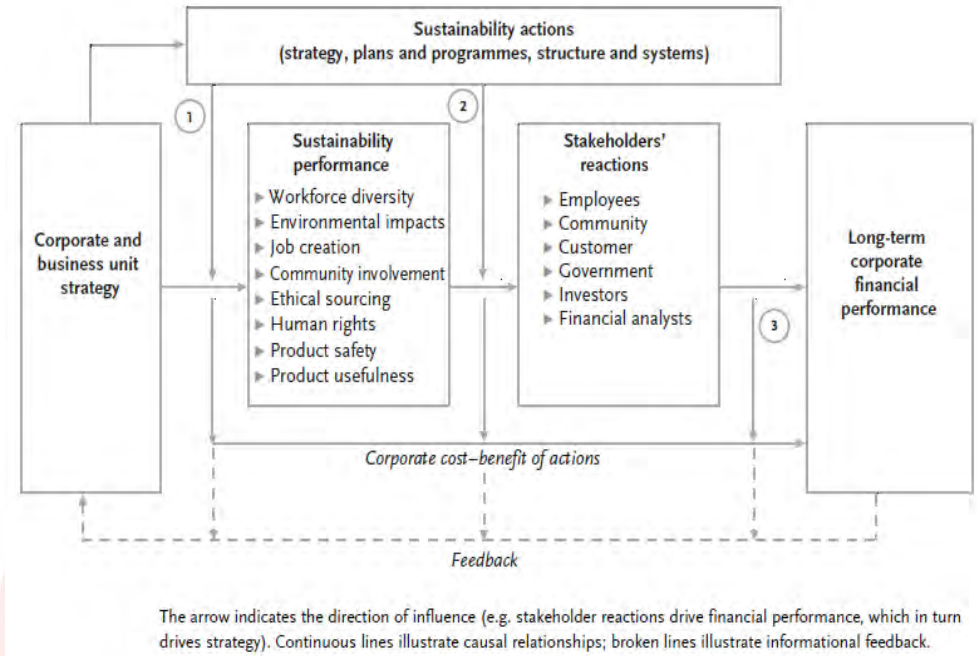
Schaltegger (2010) contends negative business case sustainability projects are typically end-of-the-pipe pollution control measures, whereas positive business case projects focus on prevention of waste or pollution and thereby improving the efficiency of economic production systems. According to Schaltegger (2010) critical to this contrast is the need for robust and effective internal management control systems to improve the economic outcomes from sustainability projects.

The link between sustainability and financial performance has been hypothesised as an inverse U relationship (Salzmann *et al.,* 2005) suggesting there is an optimal level of environmental and social performance initiatives beyond which lead to reduced financial performance. An example provided by Salzmann *et al.,* (2005) is the pursuit of high cost sustainability outcomes (e.g. zero emissions) rather than low cost eco-efficient outcomes (e.g. small incremental reductions in emissions).

It is possible the inverse U relationship hypothesis explains why empirical studies fail to show a clear positive or negative linear relationship between sustainability implementation and financial performance, as the direct link between sustainability and profitability may well depend on the type of project, whether the project pursues weak or strong sustainability objectives and what stage the organisation is at along the path of transformation to sustainability.

Figure 1 identifies a framework developed by Epstein and Roy (2001; 2003) which links sustainability actions with long term financial performance. Central to this framework are potential impacts of sustainability actions on stakeholders, identified across eight diverse sustainability performance categories covering social, environmental and economic impacts. Epstein and Roy's (2001; 2003) framework focuses primarily on the business case as they examine the link between improved financial performance as a result of sustainability project implementation. Inclusion in the Epstein and Roy framework of sustainability impacts on a diverse range of stakeholders is noted and forms an important component of the social case framework developed in this research.

Figure 1 Drivers of Sustainability and Financial Performance



The arrow indicates the direction of influence (e.g. stakeholder reactions drive financial performance, which in turn drives strategy). Continuous lines illustrate causal relationships; broken lines illustrate informational feedback.

Source: Epstein & Roy (2003, p82).

Epstein and Roy (2003) suggest their framework can improve the effectiveness of sustainability implementation by leading to the identification and prioritisation of wealth creating strategic business opportunities. This strategic component to sustainability implementation is also evident in Salzmann *et al.* (2005, p3) where the business case is defined as a strategic and *profit-driven corporate response to environmental and social issues caused through the organisation's primary and secondary activities*.

Grayson and Hodges (2001) reinforce this economic focus when evaluating sustainability projects, suggesting the value of the business case be measured by change in financial performance, cost of capital, market share and business reputation.

By way of contrast, WWF-UK (2001) expands the business case beyond economic impacts. Step one in their six step process to build a business case involves identifying significant business impacts on environment and society. Step five requires identification of sustainability actions which will create and conserve value in areas of strategic importance to the business. However the crucial final step six in the process they define for evaluating sustainability projects defaults to measures of financial performance using standard indicators such as economic cost-benefit, return on investment, and net present value.

Sprinkle and Maines (2010) emphasise the predominance of economic thinking in their six point rationale explaining why firms engage in CSR activities. Of their six reasons, three are primarily economic (increase market share, reduce production costs and reduce risk of increased costs of litigation or compliance with new regulations); one reason is socio-economic (help recruit, motivate and retain employees); and the final two reasons are greenwashing and altruism.

This brief overview of the business case for sustainability confirms a focus on the expected economic impacts of sustainability implementation. Conceptually the weakness of this approach is the inherent multidimensionality of sustainability. Sustainability as a relevant business goal is supported on the grounds that business performance is more complex than a

single dimensional economic perspective can provide. Sustainability captures this complexity within its multiple dimensions and within the inherent interconnection between these dimensions. In other words, to exclude social and environmental impacts from the analysis which supports or rejects sustainability implementation is not to consider sustainability at all.

The underlying premise of this research is there is a much broader social case for business to engage in sustainability activities; and this social case must consider the essential interconnection with environmental and economic aspects captured within this multidimensional conception of sustainability.

The social case

Within the sustainability literature, the social dimension of sustainability is the least conceptually developed (Littig & Grießler 2005; Partridge 2005; Cuthill 2010; Brent & Labuschange 2007); and there is minimal reference to a social case for sustainability (Dyllick & Hockerts 2002; Mitzenberg 1983; Hendersen 2001).

The precise nature of the social dimension of sustainability is unclear and contested (Littig & Grießler 2005; Cuthill 2010). Furthermore the quantification of the social dimension of business sustainability using financial units has proven difficult leading some researchers to suggest that sustainability is a phenomenon that will always defy precise measurement (Zadek 2004; da Piedade & Thomas 2006; Fricker 1998).

Every business causes social impacts on stakeholders (Porter & Kramer 2006) which could be either positive or negative, causing varied affect on different stakeholders. At a business level social sustainability concerns business responsibility to the social well-being of current and future stakeholders (Dyllick & Hockerts 2002), examining the human and social well-being component of sustainability encompassing human needs, human rights, social justice and quality of life.

Dyllick and Hockerts (2002, p.138) present a separate 'societal case' for sustainability against a benchmark of *'absolute positive social impact'* that an organisation could have achieved, to be made in addition to any business case. DesJardins (2007) observes that the primary goal of business is to contribute to social well-being and that profit, whilst essential to business provides the means to achieving this primary (social) goal. This essentially social perspective of business sustainability is supported within the growing corporate social responsibility literature and historically.

Historical support for this social perspective of business is provided in the form of the original corporations in the United States which were created to provide essential infrastructure and engage in domestic and international trade to serve the public good (Seavoy, 1978).

"At its origin in Massachusetts the corporation was conceived as an agency of government, endowed with public attributes, exclusive privileges, and political power, and designed to serve a social function for the state" (Handlin and Handlin, 1945, p 23).

The primary goal of these original US corporations was to meet vital human needs and the business corporation was seen to be the most effective legal vehicle for achieving this goal.

Dyllick and Hockerts (2002, p.138) suggest

"… that corporate managers will place greater emphasis on the business case while the natural or societal case will only become relevant if external systems (politics and consumers) force firms to take notice."

This view is challenged in this paper given the inherent self-contradiction of evaluating sustainability, a multidimensional concept, from a non-sustainability, single dimensional perspective. Furthermore the interconnection between these multiple dimensions is considered an essential element that cannot be excluded from an authentic analysis of the expected consequences of implementation of a sustainability project.

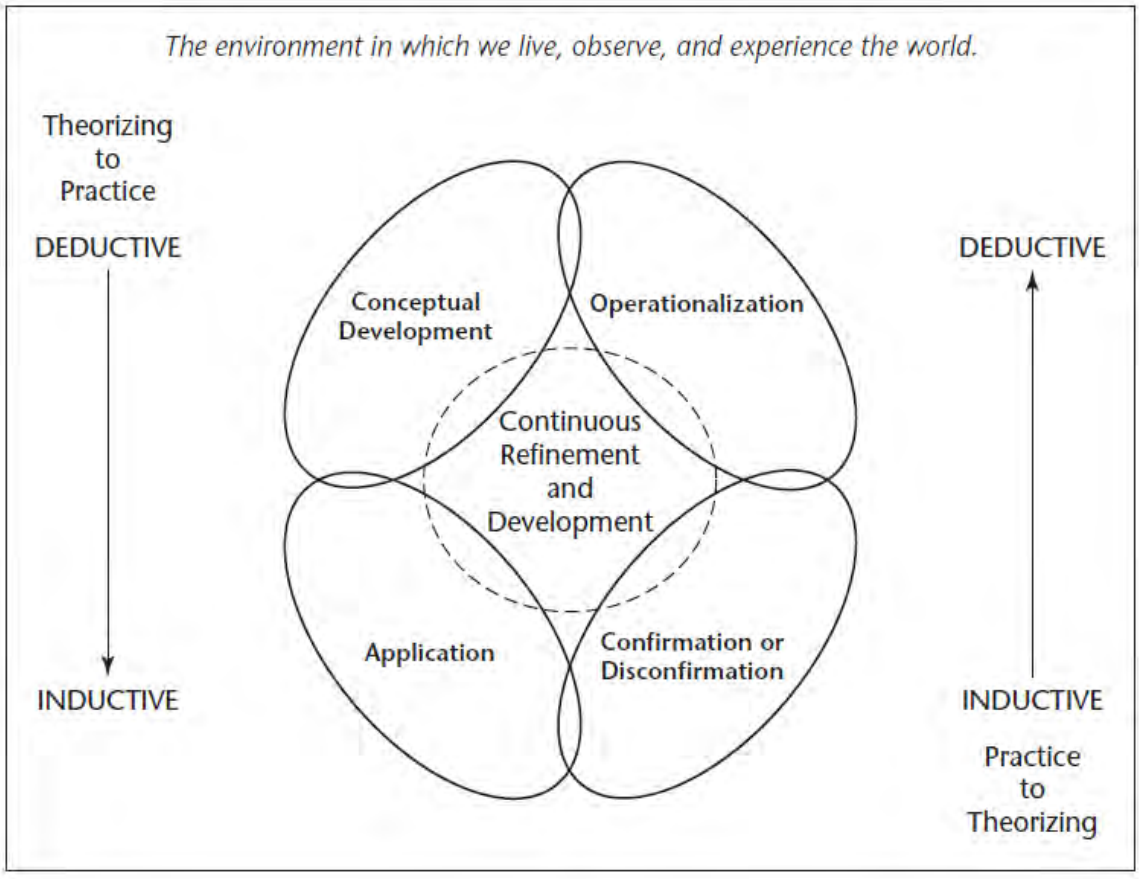
The paper now describes the methodology used in this research to develop the social case framework.

Methodology

This research began with the primary objective to provide a comprehensive framework which clarifies the precise nature of the social dimension of business sustainability. Application of such a theoretical framework would enable a business organisation to determine whether there is a social case to support sustainability implementation.

Theory has long been recognised as the underlying requirement of effective practice where it is useful for making sense of phenomena in the real world through ordering relationships among the elements (Dubin 1976, p.26). The method of theory building used in this research is depicted in Figure 2, *The General Method of Theory-Building Research in Applied Disciplines* (Lynham 2002). This model identifies the interactions among the four stages of theory building and the continuous cycle involved to lay foundations for and to develop theory.

Figure 2 The General Method of Theory-Building Research in Applied Disciplines



Source: Lynham 2002, p.231.

Theory building establishes a process for theory development by describing the phenomenon and its attributes, exploring the relationships between these components and explaining the relationships between these characteristics (Edgar & Lockwood 2010). The purpose of this first stage of conceptual development is to provide an informed conceptual framework that supplies a preliminary understanding and explanation of the characteristics and relationships of the phenomenon under study (Lynham 2002, p.231). This explanation includes

"*the development of the key elements of the theory*, *an initial explanation of their interdependence, and the general limitations and conditions under which the theoretical framework can be expected to operate"* (Lynham 2002, p.232).

Storberg-Walker (2007b) identifies five essential components in the conceptual development research phase

1) examine alternative theoretical research perspectives and processes,
2) resolve paradigmatic issues,
3) resolve foundational theory issues,
4) resolve preliminary research design issues, and
5) identify and select the appropriate modelling process.

Storberg-Walker's first phase of conceptual development allows for multiple ways of thinking about the phenomenon to be examined. In this research sustainability as a complex and contested concept with many competing views was explored from the differing perspectives of sustainability versus sustainable development; weak versus strong sustainability; sustainability as a process or state; and variations of three and four pillar models of sustainability.

The important second and third steps of resolving paradigmatic and foundational theory issues requires indentifying and confirming underlying assumptions and the examination of opposing foundational theories to assist in opening up varying possibilities for the construction of the framework (Storberg-Walker & Chermack 2007, p.517). Alternative views on the dimensions of sustainability (triple bottom line, quadruple bottom line) and the nexus between sustainability and stakeholder management were considered crucial foundational theory issues. The three dimensional process-oriented definition of sustainability which emphasises the essential interconnection between these dimensions is reflected in the social case framework depicted in Figure 3. This perspective has widespread support in the literature as it goes beyond the single dimension business case towards a social case model which reflects the integrated reality of sustainability.

The fourth phase of conceptual development is the essential step where *"careful specification of important research design issues on the front end of theory building"* is needed (Storberg-Walker & Chermack 2007 p.518). This step required important decisions to be made early in the theory building process concerning causal relationships between the components of the social case framework. Examination of causal relationships included in Epstein & Roy (2001) and Dyllick & Hockerts (2002) conceptual sustainability models assisted in this phase; with the eight sustainability impact categories depicted in the Epstein & Roy (2001) model refocused and expanded to 10 social impact categories (refer Figure 3).

This final phase involves the diagrammatical representation of the theory under construction (Storberg-Walker & Chermack 2007, p.51) enabling a systematic examination of the framework components, the relationships between these components, the causal impacts that result from these relationships and the components that are affected by this logic and reasoning. This diagrammatical representation of the social case framework is provided in the next section of this paper.

The social case framework

Figure 3 presents the social case conceptual framework.

Figure 3 The social case framework

Purpose of a Social Case	Principles of Sustainability	Categories of Social Impact	Stakeholder Relationships
Identify changes in stakeholder social well-being related to the implementation of sustainability principles in an organisation. Dimensions of Social Well-being **1.** Coherence **2.** Integration **3.** Actualisation **4.** Contribution **5.** Acceptance	1. Three dimensional definition 2. Interconnection of the three dimensions of sustainability 3. Economy as subsystem of society which is subsystem of natural environment. **Environmental** **Social** **Economic**	**1.** Governance **2.** Corporate Culture **3.** Human Rights **4.** Regulation **5.** Human Resource Management **6.** Knowledge Management **7.** Health & Safety **8.** Product Design & Built Environment **9.** Philanthropy & Responsibility **10.** Equity & Ethics	Stakeholder influence on sustainability implementation Sustainability implementation impact on stakeholders Stakeholder Interactions

The primary purpose of the social case for business sustainability is to identify changes in stakeholder well-being as a result of sustainability implementation within business, recognising five components of social well-being of coherence, integration, actualisation, contribution and acceptance as described by Keyes (1998).

Social coherence concerns interpretations of the social world, its qualities and a concern for knowing about the world in which people live (Keyes 1998). Social integration acknowledges an individuals' relationship with the community and with society and the extent and depth of

quality within that relationship (Keyes 1998). A sense of belonging (to a community) is integral to social integration. Social actualisation concerns society's potential for growth and development, where institutions and citizens operate at their full social potential (Keyes 1998).

Social contribution refers to the evaluation of an individual's social value within society (Keyes 1998) which is enhanced by their level of contribution to and how they fit within society. Social acceptance examines the character and qualities of trust, kindness and industriousness of others (Keyes 1998). Self-acceptance is also an underlying construct of social acceptance.

Critical to development of this framework are the sustainability principles presented in the second column of Figure 3, recognising the interconnection between the dimensions of sustainability and the concentric circle representation of these dimensions. Sustainability is often dissected into separate environmental, social and economic components with the disclaimer that these separate dimensions are actually connected, although Hawken (2007) suggests meaning is lost through this disaggregation process.

The possible breadth of social impacts of business is captured by the ten categories depicted in the third column of Figure 3. The categories are not mutually exclusive and overlap is highly likely, are governance, corporate culture, human rights, regulation, human resource management, knowledge management, health and safety, product design and built environment, philanthropy and responsibility and equity and ethics.

Governance focuses on management's decision making within an organisation (Sethi 2002; Kemp, Parto & Gibson 2005) and concerns four key principles of transparency, accountability, responsibility and fairness (Aras & Crowther 2008). Workplace negotiation, implementation of operating standards and conflict resolution are examples of governance issues that may cause impacts on stakeholders during sustainability implementation.

Corporate culture includes the organisation's value and belief systems (Epstein 2008). When an organisation's culture changes as a result of sustainability implementation, this could for example result in tension between stakeholders whose values become divergent (Maignan, Ferrell & Ferrell 2005). Successful sustainability implementation requires an internal value system that promotes sustainability and senior management have an important role in developing this type of corporate culture.

The human rights category of social impact directly relates to issues such as those defined in the *Universal Declaration of Human Rights (1948)* including the right to freedom of association, religious choice or freedom of speech. Business operations can impinge on these rights and sustainability project implementation must ensure these rights are upheld and encouraged as an important contribution to social wellbeing.

Regulation can impact on management, employees, government and communities by providing legal standards for business to comply with that reduce negative impacts on stakeholder well-being. Corporate codes of conduct must address sustainability to assist an organisation in meeting regulatory requirements (Epstein 2008).

Human resource management (HRM) includes labour relations, employment management and performance review. Positive employee outcomes from sustainability implementation are reliant on human resource management that has the ability to directly affect stakeholders by means of equity, personal development and well-being (Gollan 2005, p.25).

The knowledge management social impact category concerns issues such as knowledge transfer, creation, capability and strategy (Shani, Sena & Olin 2003). Knowledge

management may result in increased information flows from sustainability implementation such as increasing consumer knowledge of environmentally friendly products and their impact on environment and human health.

There is a large range of potential health and safety (OH&S) impacts both internal and external to the organisation. For example, employee welfare may be reduced by unsafe work practices and consumers may suffer from consumption of unhealthy or contaminated products.

Product design and built environment covers the physical elements which impact on stakeholders. Examples include pollution and toxic waste discharges from production operations; sick building syndrome which negatively impacts on employee health and mental wellbeing; and increased choice resulting from a more ethical and environmentally friendly range of products to choose from.

Philanthropy and responsibility includes direct social impacts such as charitable donations and responsible business actions such as releasing employees for volunteer programs with social and environmental aims (Maignan, Ferrell & Ferrell 2005, p.964).

Equity and ethics concerns the specific sustainability related goals of intra and inter-generational equity or justice in distributions between present and future generations, and for example equal employment opportunities.

The stakeholder relationship component depicted in the fourth column of Figure 3 identifies the dynamic relationships of the impact that sustainability implementation has on stakeholders, the influence that stakeholders can have on sustainability implementation and the interactions that stakeholders may have with other stakeholders. For example, local communities can create pressure which influences managerial decisions concerning new project implementation. Furthermore interaction between management and other stakeholders, for example at stakeholder consultation meetings, can inform all affected parties as to potential social impacts of the proposal.

The next section of this paper uses a well known case study from India involving bottom-of-pyramid sustainability project implementation to demonstrate application of the social case framework.

Coca-Cola in Kerala

The case of Coca-Cola in Kerala, India is used to demonstrate application of the social case framework depicted in this paper as Figure 3. The Kerala case provides the opportunity for comparison and connection between the business and social cases drawing on a combination of facts and claims that have become publically available after the decision to implement the project. There is no suggestion that the impacts of the project in Kerala should have been forecast by Coca-Cola prior to implementation, although implications of the case for sustainability decision making are discussed later in the paper.

In 2000 the Hindustan Coca-Cola Company set up the bottling plant in Plachimada, a small village in Kerala on 34 acres of land classified as ‘arable’ by the Indian Government. Although the bottling plant was located in a drought-prone region of India it was commonly referred to as the ‘rice bowl of Kerala’ as farms are irrigated by a series of water reservoirs and canals which surround the bottling plant.

The underlying support for establishing a bottling plant in Kerala was based on the idea of bottom-of-pyramid marketing which pursues market growth by connecting globalisation to the idea of inclusive capitalism

"…the billions of aspiring poor who are joining the market economy for the first time…For companies with the resources and persistence to compete at the bottom of the world economic pyramid, the prospective rewards include growth, profits and incalculable contributions to humankind" (Prahalad & Hart, 2002, p 1).

Some estimates suggest there are 4 billion people living in poverty with US$5 trillion of purchasing power (IBLF 2007) although these estimates are varied and highly contested. Karnarni (2007, p 90) summarises the BOP proposition as follows:

▪ *There is much untapped purchasing power at the bottom of the pyramid. Private companies can make significant profits by selling to the poor.*

▪ *By selling to the poor, private companies can bring prosperity to the poor, and thus can help eradicate poverty.*

▪ *Large multinational companies (MNCs) should play the leading role in this process of selling to the poor.*

Prahalad and Hart (2002) call for new business strategies to exploit the bottom of pyramid opportunity. These include the design of robust, smaller products, produced by labour intensive rather than resource intensive production systems, sold at high volume and low price, distributed using local labour and knowledge, and pay per use strategies replacing upfront purchase of assets.

Coca-Cola's business plan for their Kerala bottling plant included many of these strategies, specifically the design of small 200 millilitre bottles, local production, using the high volume, low price strategy, and drawing on cheap local labour where possible. However Coca-Cola's experience in Kerala was quite different to that suggested by the bottom of pyramid proposition described previously by Karnarni (2007).

Opponents of the Kerala bottling plant accused Coke of drawing up to 1.5 million litres of water each day through deep wells to enable the company to bottle its familiar Coke, Fanta, Sprite, Thumbs-Up and bottled water products. Local villagers in Plachimada reported problems within six months of the plant becoming operational. Their complaints were that fresh water had become saline and hard, local crop yields had fallen, and villagers were experiencing a range of health problems including skin disease and breathing difficulties (Koonan, 2007).

It was also claimed (Hills & Welford, 2005) that Coca-Cola's Plachimada bottling plant caused

1. Water shortages in the surrounding village

2. Pollution of ground water and soil from the plant's waste water

3. Pollution of farm land from toxic waste sludge sold as fertiliser to local farmers

4. Potential health risks from products sold which contain chemical residues.

All of these claims are denied by Coca-Cola.

The Kerala government agreed the plant was extracting excessive amounts of ground water leading to shortages of drinking water, and found high levels of cadmium in the sludge sold as fertiliser to local farmers. A resolution was passed on 7 April 2003 not to renew the company's license to operate in Kerala (Hills & Welford, 2005).

A 14-member committee constituted by the Kerala government to assess socio-economic damage caused by the bottling plant in the Plachimada village estimated the cost of damage to be approximately US $47m (Singh 2011). The Kerala Government passed a law enabling

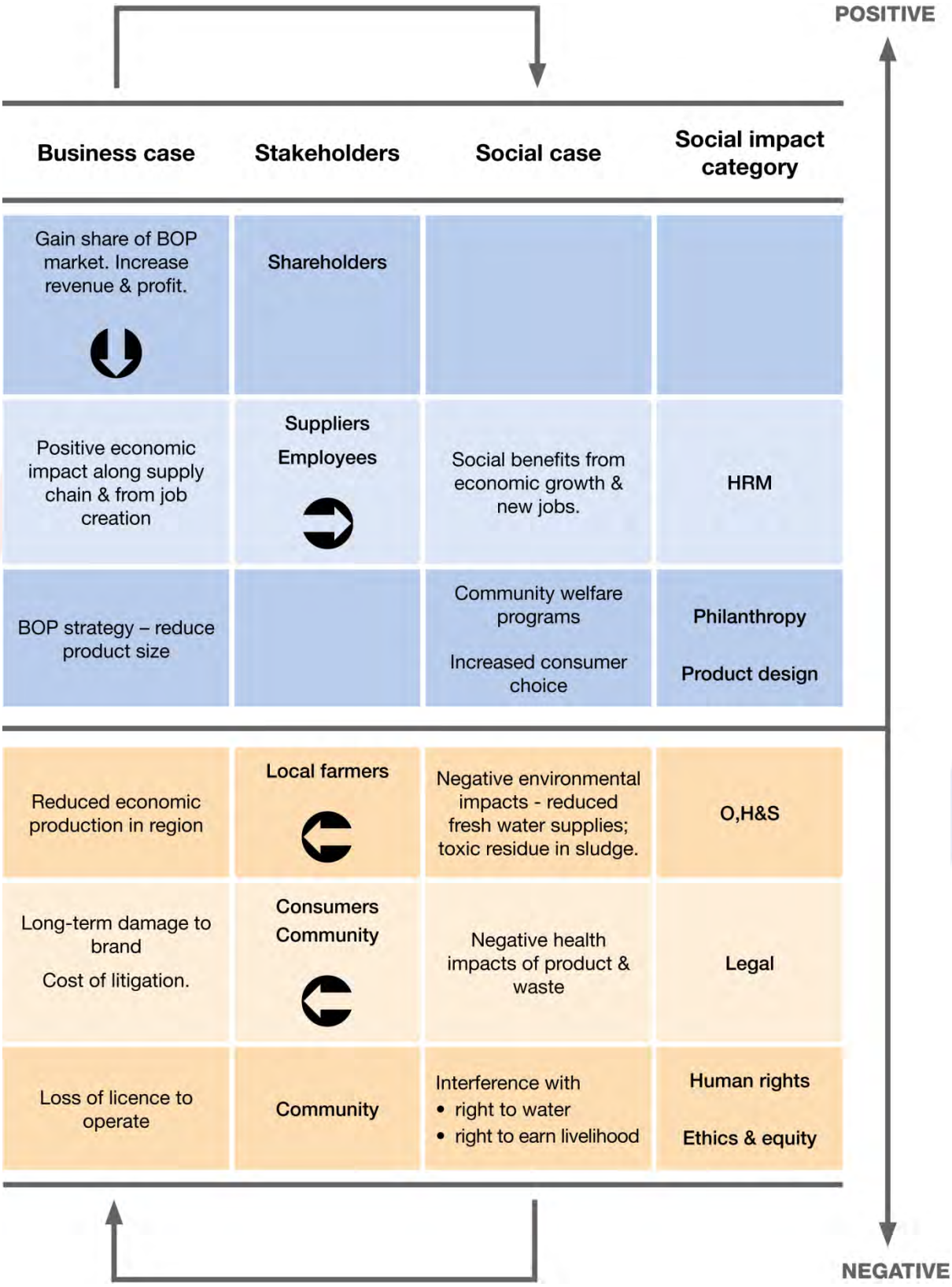
people to seek compensation from Coca-Cola, and later banned the production and sale of Coca-Cola in Kerala.

In April 2005 the High Court of Kerala ruled that Coca-Cola could extract up to 500,000 litres of water per day from common groundwater resources at its Plachimada facility in southern India (Burnett & Welford, 2007).

In September 2006 Coca-Cola challenged the Kerala state government ban on the production and sale of their products on the grounds that only the central government of India had the authority to ban food products. The Indian High Court agreed with Coca-Cola and reversed the ban (Burnett & Welford, 2007).

Figure 4 summarises the sustainability impacts of the Coca-Cola bottling plant in Kerala.

Figure 4 The Social Case of Coca-Cola in Kerala



The expected positive economic consequences from setting up a bottling plant in Kerala (shown in the top left 'Business case' column of Figure 4) were increased revenue and profits resulting from expanding market share into the bottom-of-pyramid (BOP) segment based on a

strategy of selling Coca-Cola's products in smaller, lower priced units. These positive economic benefits did result in positive social consequences (depicted in Figure 4 by the first arrow in column 2) flowing directly from economic growth which directly benefited employees at and suppliers of the new Plachimada bottling plant. Additional social benefits flowed from Coca-Cola's increased philanthropic activities and the opportunity for some BOP consumers to enjoy a wider range of product choice.

However the negative environmental and social impacts resulting from the Plachimada bottling plant were significant. Local community concerns that the plant caused reduced supplies of fresh water, sold products containing toxic residues, sold toxic sludge to farmers and polluted local ecosystems with waste water which were supported by the Kerala State Government, turned local and international communities against the Coca-Cola group of companies.

Additional concerns were raised given the impact of the bottling plant on the local poor who were confronted with reduced supplies of fresh water perceived to be replaced with a range of products which were considered to be unhealthy, beyond their financial means given their low daily incomes and above the cost of fresh drinking water. These concerns expanded to represent claims that Coca-Cola had violated the rights of the local community by stealing water thus depriving them of access to fresh water essential for their health and livelihoods (Koonan 2007).

The interconnectedness between social and economic impacts is demonstrated in Figure 4 where negative social impacts are linked to negative economic impacts. Loss of income from falling agricultural production, cost of defending court proceedings taken against Coca-Cola, the economic cost of loss of brand image and the cost of attempts to rebuild the Coca-Cola brand in India and internationally, rendered the Kerala project uneconomically viable leading to Coca-Cola's decision to abandon the plant.

What appeared to be a positive business case prior to project implementation collapsed under the weight of negative economic consequences caused by negative environmental and social impacts. Figure 4 shows the breadth of social impacts experienced by a diverse range of stakeholders and the interconnection of these social impacts with environmental and economic impacts.

Although the authors are not claiming that Coca-Cola should have forecast all of the negative social and economic consequences depicted in Figure 4, it is feasible that using a multidimensional sustainability framework to evaluate the expected viability of a sustainability project will increase the likelihood of gaining a clearer understanding of a project's impacts prior to implementation. This is particularly true of secondary impacts caused by interconnectedness between sustainability dimensions, such as the negative economic consequences which occurred as a result of the negative environmental and social impacts. This essential interconnectedness is lost in a single dimensional business case scenario.

The Kerala case represents the authors' first attempt to apply the social case framework and not surprisingly the Figure 4 social case application differs in some respects from the Figure 3 social case framework. Whilst the general structure of social impact categories on various stakeholders is evident in Figure 4, the difference lies in the integration of the business and social cases. Whereas Dyllick and Hockerts (2002) suggested a separate societal case was needed in addition to the business case, the Kerala case shows the benefit of integrating these cases.

Conclusions

The sustainability literature contains a modest number of articles discussing the business case for sustainability assumed to be an economically focused analysis designed to answer the specific question as to whether the proposed project is expected to increase financial performance. There is minimal discussion in the sustainability literature concerning a systematic approach to determining if there is a social case for business to pursue sustainability.

In this paper a theoretical framework developed using Storberg-Walker's (2007b) five phase model of conceptual development is presented as an alternative framework for evaluating the viability of a sustainability project. The case study of Coca-Cola in Kerala, India used to demonstrate application of the social case framework demonstrates the interconnectedness of the social, environmental and economic dimensions of sustainability, as well as the benefits of evaluating a proposed sustainability project from the broader multidimensional sustainability perspective.

Critical to the failure of the Kerala bottling plant was the interconnection between negative environmental and social impacts which led to negative economic impacts in the form of reduced production, reduced sales, litigation costs and the need to reinvest in the Coca-Cola brand which suffered significant loss of value. Although there is no suggestion that Coca-Cola should have predicted all of the negative social impacts which occurred in Kerala the application of the social case framework presented here would increase the organisation's understanding of potential impacts prior to implementation.

Dyllick and Hollicks (2002) suggested a societal case in addition to the business case. This paper builds on this recommendation by linking the social case to the business case, thus demonstrating the essential interconnection between environmental, social and economic dimensions of sustainability. It is proposed this combined social-business case framework become the focus of further research.

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Biomass Gasification as a Sustainable Energy Technology for Small Food Processing Industry

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Abstract:

Food processing industry is one of the most important sectors in Thailand. It is a very energy intensive industry where large amount of fuels are consumed for hot water and steam generation used in processing food. Liquefied petroleum gas (LPG) or waste woods are generally used in small sized factories as energy source via combustion. LPG is expensive so biomass is an obvious alternative option. However, for a small combustion system, direct burning of biomass can be problematic owing to low efficiency and excessive emissions. Alternative conversion technology that offers better performance should be employed instead. In this work, gasification was adopted to provide heat for processing and manufacturing of fishballs, in place of existing biomass firing system. A downdraft fixed-bed gasifier system was designed, built, and installed. Waste woods were thermally converted to producer gas. The gaseous fuel was then fed to a burner to supply hot water for the factory. Test results showed satisfactory operation. Gasification of waste woods could provide required thermal input with improved overall thermal efficiency, compared to existing combustion system. Preliminary economic analysis revealed that the factory can save almost 500 Euro a month, with a return on investment in less than 6 months.

1. Introduction

Food processing industry is one of the most important sectors in Thailand. Fish balls are popular in Thai cuisine. Usually, they are fried, grilled or cooked in noodle or curry. Typical fish balls are a mixture of de-boned fish flesh, starch, salt, sugar, monosodium glutamate, and water. Once the paste is prepared, it is formed into a ball shape, put into warm water, and allowed to set. After setting, fish balls are cooked by dropping into hot water, followed by chilling with cold water. After draining, they are packed, and ready for cold storage and subsequent distribution to marketplace. Fish ball manufacturing process is energy-intensive, consuming large amount of fuels. Energy cost represents a major fraction of initial cost for fish ball processing. Normally, thermal energy is provided from wood burning which may have serious socio-environmental impacts including emissions of greenhouse gases, smoke, and tars, leading to complaints from neighboring communities. Direct firing of biomass in furnaces, semi open pits, and other open burning application is notoriously poor. Combustion efficiency is generally low with high smoke and noxious emissions, and process control is difficult and limited. This will bring about more serious air pollution and adverse effect on human health, especially those workers who are directly exposed to the emissions.

Alternative utilization method is therefore needed. Gasification offers optional conversion technique for the biomass residues available that has high energy efficiency and environmental acceptability (Chopra and Jain, 2007; Kirubakaran et al., 2009). Gasification is a thermochemical processing of a fuel into producer gas. The process produces combustible gases like CO, H_2 and HCs, from the following reactions (De Bari et al., 2000);

Gasification:

$$\text{Biomass} \rightarrow \text{char} + \text{tar} + \text{gases } (H_2, CO, CO_2, CH_4) \quad \text{(i)}$$

Thermal decomposition:

$$\text{tar} \rightarrow \text{gases } (H_2, CO, CO_2, CH_4) \quad \text{(ii)}$$

Generation of simple-to-use gaseous fuels from solid materials makes gasification very attractive. Burning of this combustible gas is cleaner, and process control is simpler than combustion of solid materials. Many kinds of biomass materials have been successfully converted, including woods, grasses, herbaceous plants, energy crops, agricultural residues, and solid wastes. The hardware involved is relatively economical for use in small scale enterprises and in rural areas. Several types of biomass gasifiers have been developed and demonstrated. Among the most popular design of gasifier adopted was downdraft system.

In this work, waste woods have been utilized as a source of clean energy via gasification. A simple downdraft fixed bed gasifier system was developed. It was installed and operated at a small fish balls manufacturing factory, with the aims to reduce operating cost of current practice, and to demonstrate a cost effective and practical producer gas burner to provide process heat with appropriate gasification technology. Experimental data obtained from the operation were presented. Analysis of its energy use and operating cost was conducted, and compared with existing combustion system.

2. Methodology

The fish ball factory is in Samutsakorn, Thailand. This small enterprise produces fish balls that are distributed and sell locally. Its 3-m^3 hot water container is heated by a locally made furnace, consuming about 60 ton of fuelwood a month. This costs around 1500 Euro per month (1 Euro = 40 Thai baht, exchange rate on March 2011). Cost of fuelwood tends to increase as supply is becoming difficult. Furthermore, the factory is situated near residential area where smoke and emissions may be offensive, especially during cold seasons. Existing wood fired furnace was modified to accommodate a gasifier and a gas burner. Waste woods with heating value of 16 MJ/kg were used as fuel feed. Limited test run was carried out to evaluate performance of the system.

A single-stage, downdraft, throat-type, fixed-bed gasifier was designed and built (shown in Fig. 1). The gasifier components included an insulated cylindrical reactor, a rotatable grate, an air drive, and an ash pit. Loading of fuel feedstock was done from the top, piling on the grate. The reactor wall was made of firebrick and covered with a steel sheet. Air was induced through circumferential holes by a fan downstream. The gasifier core was designed such that a cross section area was reduced downstream of the air inlets to form a throat or constriction. The reactor volume was designed to require refueling once every two hours when working at rated capacity. The grate area of 0.13 m^2 was designed from specific gasification rate of 270 kg/h/m^2 and the fuel feed rate of 35 kg/h. Ash formed was removed from the gasifier by the rotatable grate and fell into a water sealed, ash pit. The volume of the ash pit was sufficiently large to allow long hour operation without ash removal.

The system consists of the gasifier, a gas conditioning system and a gas burner. Bottom of the main reactor was tightly sealed by water. The gas burner was put in place beneath the existing water tank used for boling. Initially, a small amount of burning charcoal was used to establish a fire on the grate inside the gasification reactor. The induced draft fan was started, drawing air in to sustain combustion. Immediately afterwards, the waste woods were loaded, and the lit was closed. Air was regulated by valves in such a way that combustible producer gas was generated. This would take about 20-30 min for a stable flame at the gas burner to be established. Producer gas was utilized to provide hot water to process fish balls.

Fig. 1 Biomass gasifier - burner system setup

Measurements were taken by monitoring fuel consumption rate and amount of water used on an hourly basis. The gas flow rate was measured with a volume meter. The cool, dry, clean gas was sampled using gas bags and analyzed on a Shimadzu model GC-8A gas chromatograph for measuring volumetric concentration of H_2, CH_4, CO, CO_2, O_2 and N_2. Standard gas mixtures were used for quantitative calibration. Gas temperature at the gasifier exit and flame temperature were measured with type K thermocouples.

3. Results and Discussion

Operators were trained to run the system by a team of engineers and technicians. The gasifier was able to start between 5-15 min and attain steady state operation from cold start in about 30-60 min. Combustion zone in the gasifier may be viewed through an observation aperture. After attaining steady operation, the gasification system appeared to run smoothly. Producer gas fueled stable flame was established. No tar problem and no visible smoke were observed. As a precaution, the reactor was poked at regular interval to avoid biomass flow obstruction due to bridging, throat or channel formation.

Several test runs on the system were carried out. Producer gas could be ignited successfully in which bright orange flame was established. Gas production rate was found to be about 450 $m^3/h/m^2$. The gas temperature leaving the reactor was found to vary from 250-350^oC. Composition of the producer gas was 10-15% CO, 10-15% H_2, 2-3% CH_4, 10-20% CO_2, 3-5% O_2, and balance N_2. The gaseous fuel's lower heating value was estimated to be about 3.70 MJ/m^3. This may be attributed to low percentages of CO and H_2, hence low value of the heating value of the producer gas. In comparison with those reported in the literature (shown in Table 1), CO and H_2 obtained in this work were indeed comparatively small, resulting in relatively low value of heating value.

Table 1 Comparison of gasifier performance with literature

Reference	feedstock	CO (% v/v)	H_2 (% v/v)	LHV (MJ/m^3)
This work	Waste wood	10-15	10-15	3.7
Dogru et al. (2002)	Hazelnut shells	21	13	5.0
Zainal et al. (2002)	Wood chips	24	14	5.3
Sharma (2009)	Acacia wood	22	12	4.2
Sheth and Babu (2009)	Waste wood	22	12	6.3
Erlich and Fransson (2011)	Wood pellets	17-25	10-13	4.1-5.4
Tippayawong et al. (2011)	Cashew nut shells	17	5	3.5
Sharma (2011)	Hard wood	19-23	11-13	3.5-4.0

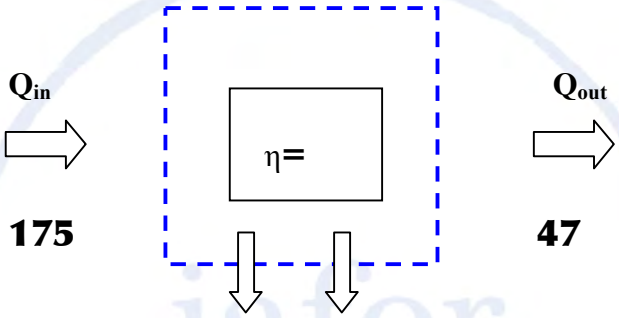

Fig. 2 Energy conversion in the gasifier – boiler system

About 10% of the biomass feed input was left as bottom ash. Visual inspection of ash showed some tiny bits of charcoal. It was worth noting that no clinkering or agglomeration of ash was observed. The thermal energy output was about 50 kW which was sufficient for generating hot water for fish ball processing in the factory. Fig. 2 shows energy diagram of the new system. From the rates of hot water generated and biomass fuel consumed, the system thermal efficiency was estimated to be 27%, a significant improvement from the existing hot water generator system with only 15% efficiency. The newly introduced system can save fuel woods at around 20 ton a month. Up to the time of reporting, the system has been in use for over 12 months. Results were consistent throughout the field test runs. The owners were happy, and satisfied with the installation of the gasifier system, in place of the existing furnace.

Economic performance was evaluated, based on analysis of a simple period to positive cash flow, where the initial investment and additional operating costs, and the wood fuel cost savings were considered. Positive cash flow was reached when the investment and cumulative operating costs were equal to the cumulating fuel cost savings. In this simple analysis, no discount rate was taken into account. The overall installation cost included costs for an induced draft fan, gas burner, refractory and structural materials, piping, insulation, painting, engineering design and construction expenses. The additional operating cost was from maintenance cost and miscellaneous operating materials associated with the gasifier system that would not be present in the wood-fired furnace. The gasifier system required an investment of about 2800 Euro and an additional operating cost of about 20 Euro a month. Saving in fuel cost was approximately 500 Euro a month. This resulted in a simple period to

positive cash flow of less than six months. This system was economically attractive to potential users because its useful life is expected to be several years.

Combustion of producer gas was much cleaner than burning waste wood directly, hence complaints from neighbors were reduced. Smoke and noxious gas emissions were expected to decrease significantly. Workplace environment was cleaner. Effect to human health, especially the factory workers was reduced. There was also skill development among the employees who trained to operate the system. There are plans to implement similar modification to other similar small and medium enterprises in the country. This factory can become a demonstration site for others to come and learn from their experience.

4. Conclusion

Gasification as sustainable energy conversion technology for solid biomass materials was considered in this study. The downdraft throat-type gasifier was found to perform satisfactorily well with waste woods for hot water generation. Producer gas generated was successfully utilized to fuel a burner at required thermal output rating for processing fish balls. Overall thermal efficiency was significantly improved, leading to significant fuel saving. The operators and owners were satisfied with the system. Analysis results showed that the gasifier system operation was economically attractive.

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Design Solutions from the Past for Housing Interiors of Today

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Abstract:

The history of interior architecture, as a recognized profession, spans a little more than a century. However, many examples of interior architecture applications can be found throughout the history of built environment. This is an indicator of a conscious tradition of interior design, whether it is done by an artisan or an interior architect.

A good indicator of the quality and comfort of an interior space is how parts of this interior are related to each other and how their corresponding functional requirements are met. Previously conceived interiors are full of instances of solutions to everyday interior design problems. The raising interest on interior design services emphasizes a special focus and sensibility on this subject.

Even though there are courses mentioning history of interior design, modern interior architecture programs overlook ancient interiors, and focus on relatively more modern instances. Although it seems effective at first, this approach results in many effective ancient solutions go unnoticed, even though many of today's interiors pose same problems that were already solved thousands of years ago.

In this study, ancient housings of the past from Hittites to Egyptians to Greeks will be examined. The solutions for functional requirements of the ancient housings that shed light to today's design problems will be examined and their possible modern applications will be discussed. It is aimed that, this study will contribute to the vision of contemporary interior architects with a fresh look to ancient interiors.

INTRODUCTION

The tradition of defining interior spaces and developing functional and aesthetical solutions to spatial problems has been continuing since the pre-historic times. Many examples of interior space applications can be found throughout the history of built environment. Interior space design recognized as a profession at the end of the 19th century, in the United States. Later in the 19th century, following the 2nd World War, interior architecture/design became a professional branch, institutionalizing and receiving widespread attention (Pitrowski, 1989; Veitch, 1992).

Since the 1950s environmental concerns have been expressed more and more vigorously as the symptoms of environmental destruction ranging from widespread habitat destruction, loss of biological diversity, pollution, depletion of resources to global climate change, become more obtrusive (Kellert, 2005). As a result of these events the concept of sustainability generated an increasing interest and steadily gained importance over the last 60 years.

McLennan (2004) defines sustainability as something that is able to be maintained. However, he also adds that this definition does not accurately portray the concept of sustainability, which involves improving the relationship between humanity and the natural world. Grounding from this philosophy, sustainable design implies a sense of responsibility and respect for natural systems, resources, people and the cycle of life (McLennan, 2004). The aim is to maximize the quality of the building environment while eliminating negative impact on the natural environment. As Russell (1989) indicates, there is a need for a building metaphor that somehow encapsulates the idea of co-operative community that is responsible and respectful toward the earth and each other.

As more environmental problems surfaced, sustainable thinking become a responsibility of the designer rather than a way of distinguishing oneself, and this way of thinking become an integral part of the design process. With sustainable design, the issues concerning the designer are expanded. The definition of good design started to include criteria that were overlooked in the past. The concepts such as firmness, commodity and delight emphasized by Vitrivius (1998) are improved to a more intricate thinking, resulting relationships generating more complex design problems. Environmental responsibility and human health become important concerns of the designer, therefore shaping the design product.

Sustainable design can be defined as a philosophy rather than a style or a method. Since sustainable design signifies a design methodology, not having aesthetic or stylistic qualities, it can never go out of style (McLennan, 2004). Sustainable thinking emerged as the awareness of the environment increased, not as the common taste of the society shifted. As a result it can be said that sustainable design is here to stay, not getting affected by trends or time.

SUSTAINABLE DESIGN AND HISTORY OF BUILT ENVIRONMENT

An important aspect of today's sustainable design scene is the idealization of the innovations and solutions of vernacular architecture, developed over thousands of years with the contribution of civilizations all over the world. The belief is that the bulk of knowledge

accumulated by our ancestors was the pinnacle of development in sustainable design. However, it is usually implied that the situation has worsened with time. This point of view advocates that all sustainable design ideas exploited today are not brand new, but revised and adapted versions of past innovations and solutions (McLennan, 2004).

Even though, this point of view claims that the start of sustainable design is vernacular architecture, it is obvious that the innovations and solutions of the past did not have a basis of sustainable philosophy or aimed at building sustainable architecture. Our ancestors were not ecologically superior, no more adept than modern people. The resources, tools and technology available at any period, on any geography asserted limitations on design. For instance, people had to build with local materials because of expensive transportation or climate conditions had to be utilized since there was no electrical equipment available to improve comfort. The so called ecological superiority is not a result of having a better understanding of environmental consequences of one's actions. The real reason is that, said solutions are reached through extensive trial and error processes, which happened to be sustainable since there was no unsustainable option. Secondly, there were no known negative impact on nature and the effects of human constructions were not widely known until the 1950s (McLennan, 2004).

The sustainability aspect of vernacular architecture arised from the necessity and a lack of technology, however, the end result was after all sustainable. However, following the industrial revolution, technological developments provided cheaper and quicker solutions to the problem faced by vernacular architecture. As a result architects and designers turned their face from the past, but spatial quality quickly declined. The daylight was not utilized properly, resulting in interiors that needed artificial lighting in broad daylight; the air and heating high rise buildings had to be regulated continuously for comfort.

Such technological innovations, as air conditioning and combustion heating system changed the relationship between the climate inside and outside. Therefor building design and ultimately spatial design responded to this change. Another example is the invention of electric lighting, and resulting decrease in care for designing natural lighting. Until the invention of electric lighting, buildings were designed to be narrow and allowed as much light as possible, as long as possible. Contemporary interiors usually have to utilize electrical lighting even through the day. One last concern introduced with industrial revolution was the innovations in transportations, which eradicated the limitations of constructing with only nearby materials. This, as a result, affected the architectural character; buildings became similar looking defying cultural forms and aesthetic.

As a conclusion, the resulting situation can be defined as technological innovations and solutions making the designer less concerning on environmental issues. Since technology took care of all comfort problems, the role of the interior architect/designer is reduced to providing basic layout solutions and determining the looks of the interior space.

SUSTAINABILITY IN THE HISTORY OF ANCIENT HOUSING

There are researchers claiming that the origins of sustainable design can be found in our biological beginnings. Since the human biology is an extension of nature and humans learned

to live harmoniously within nature, adapting every facet of the natural world. This way of living is no different than any other species until humankind learned to modify its surroundings and creating shelters, finding ways to regulate the system that envelopes himself/herself.

The history of built environment can be summarized as a pursuit for ultimate comfort and security. Even though first examples of interior spaces were shelters, with challenges asserted by climate, regional necessities and available resources, spatial solutions become increasingly more complex. The relationship between the elements of an interior space and solutions to the corresponding functional requirements are effective indicators of the quality of an interior space. Historical interior spaces are full of solutions to everyday design problems, and these solutions have evolved over a long period of time. In this paper, sustainable solutions from the history of ancient housing is categorized according to three civilizations; Hittite, Ancient Egypt and Ancient Greek.

Sustainable Housing in Hittites

As in other ancient cultures, sustainability was a side benefit of the materials and construction methods employed. The materials of the ancient Mesopotamian house were; mud brick, mud plaster mud roofing with poplar structure, wooden doors and door frames. All of these materials were naturally available around the cities (Postgate, 1992). Stone was also another important architectural material. The development of masonry and sculpture is regarded as the result of the extensive usage of stone (Darga, 1992). Another material, limestone, was relatively easy to form and abundantly found in the vicinity of Boğazköy. The examinations on the rock structures that exist in the area indicate that there were quarries (Naumann, 1998).

Another solution to comfort problems proposed by Hittites, houses were arranged in frequent and compact patterns, bordering on one another leaving small separations. This is useful in both winters and summers, since it increases thermal inertia. Not only the surface are that is exposed to sunlight is reduced in summers, in winters, due to a smaller area that is occupied by more densely, the heating would also be less problematic, and bordering houses would decrease the insulation problem therefore reducing the loss of heat to the atmosphere.

Sustainable Housing in Ancient Egypt

The information on the features and materials of interior spaces of Ancient Egypt is acquired from the paintings found on temple walls and on pottery (Blakemore, 1997). These drawing provide information not only on spatial relationships but also on the relationships between the individuals of the period. Since Ancient Egypt's residential architecture was not aimed at permanency, the materials being indurable against the erosion in the desert, therefore no residences were left intact. Details related to ventilation, air conditioning, egresses, pillars, columns, courtyards and opening features were acquired from ancient paintings.

In Ancient Egypt spatial features and relationships have been affected by the Nile River, the vegetation around the river, the materials and manufacturing techniques available in the region and the climate as well as social hierarchy and religion (Pile, 2000). The silty soil accumulating in the Nile River on a yearly basis was an important raw material for plaster,

which was an important construction material for all socio economic levels. Besides plaster; mud bricks made out of the soil from the Nile River, as well as stone and timber were important construction materials, limestone being the most common stone found in Egypt.

Straight terrace roofs, open courtyards and limited number of relatively small openings were a result of the extremely bright sunlight, suffocating heat, scarce rainfall and powerful winds of the region (Blakemore, 1997). Climate directly affected the architectural form of the housing and therefore the quality of the interior space. The interior spaces were introverted and shadowy, providing protection against the sun and wind.

A cultural sustainability feature was the uniqueness of the stonework in Ancient Egypt, which is an outcome of the application of frescos. When creating the frescos, a white undercoating plaster was applied before painting the fresco and later varnish and wax, again found in the nearby region, were applied over the fresco to make it more durable (Blakemore, 1997). Thanks to this process, we can understand the architecture of the period.

Sustainable Housing in Ancient Greece

In Ancient Greece, the materials used in the interior space were also regional. Marble was one of the most important and it was abundant in the surrounding quarries. Structural features arised from the utilization of regional materials such as marble and limestone defined the character of the interior space. Like Hittites and Ancient Egypt, structural walls were constructed out of dried mud; plaster was applied over for decorative applications (Özsavaş, 2011). Stone and timber were also other important structural materials.

In Greek Architecture, the basis of the plan was formed by the Megaron. Megaron consisted of three units that were interrelated to each other. These were a colonnade, a storage unit and a hall (Roth, 2002). The emphasis in the interior space was on the courtyard which all spaces were connected to. The architecture was introverted and privacy was valued, as a result connections between rooms were provided through corridors between every room. Axial planning was very prominent in spatial arrangement and natural light was the determining element. Courtyard plans, use of colonnades for spatial definition as well as structural support, affected the interior design thinking followed after Ancient Greece.

Water was an important element in the interior space in the Ancient Greece architecture (Pile, 2000). Pools of water in the interior space not only provided humidity but also improve the lighting by reflecting and refracting sunlight. In order to provide water for the said pools and to introduce more light into the interior, skylight-like openings on the ceilings were used.

SUSTAINABILITY IN SPATIAL HISTORY

As Guy and Farmer (2001) states, “sustainability means living within the constraints and possibilities imposed by these characteristics, and as a design strategy, bioregionalism draws inspiration from indigenous and vernacular building approaches. These traditional building forms are seen as indicative of the way in which rooted cultures have naturally evolved appropriate lifestyles adapted to their particular physical environment” (p. 144). This statement clearly emphasizes the importance of the historical architectural knowledge that can well be used as the sustainable alternative in many situations.

In the context of sustainability in ancient housing, regionalism is an important aspect of sustainable design which appeared more than ten thousand years ago. Responses to design problems change dramatically according to changes in the climate zone. Regionalism keeps the balance between resources, as different geographies and climate zone would provide different resources. Therefore resources won't be depleted for answering the needs for other regions. Additionally, structures that are built out of place could later be returned to the land when their functional life is over. This way of conservation-sustainability approach has been the norm in all pre-industrialization civilizations. Buildings were re-used and buildings materials were recycled.

The negative side of attaining comfort through design by harnessing natural forces is, that complete control over every variable is impossible to achieve. For instance, in order to attain heating comfort, vernacular architecture relied on solar income and the burning of biomass. With this method, the environmental impact was small and limited to the total output of the system. However, a homogenous heating was never achieved. Climatic conditions were extremely imposing on design features, however as Coch (1998) states, this situation did not limit the number of solutions for a given comfort problem. This indicates that the belief that every unique climate leads to same design solutions is wrong and also emphasizes that although climate conditions are limiting there is an abundance of solutions waiting to be explored by the designer.

Another important aspect of vernacular residential design is the nomadic living inside the structure. In this way of living, harnessing natural powers for comfort required that the residents had to move from space to space according to seasonal changes, or even daily sunlight direction changes. Even though dwellings stayed permanent, residents were nomadic inside the building. Courtyard was an important architectural element for this sort of nomadic living inside the structure. The courtyard created an ornamental aspect that created patterns of light and dark but more importantly, being shady and cool in summers, it provided a detached residence. It protected the residents from wind while providing an open space. Also fountains have provided humidity and a sensation of coolness in dry climates.

CONCLUSION

Contemporary sustainability solutions achieved with technology are important, however, proposed technological solutions might conflict with cultural sustainability. As Ujam and Stevenson (1996) points out, adding insulation made from synthetic materials or [incorporation] of Arabic wind towers as an [element] to an office block does not integrate a so called green solution in terms of cultural considerations. Therefore the cultural background research and knowledge becomes an important aspect of the design process. Vernacular architecture is ultimately a cultural richness, and sustaining cultural elements is actually sustaining the human cultural diversity, which is an important aspect of sustainable thinking. Sustainability is not only about conserving the richness and diversity of life on earth, it is also sustaining the culture.

There is no doubt that knowledge of the history of interior architecture/design is beneficial for the designer, but it is especially beneficial in the context of sustainable design. Unfortunately there is an obvious lack of such knowledge on the designer's part. Even though courses on the history of built environment, the history of art and the history of design are a part of the standard interior architecture/design curriculum, as indicated by ECIA (European Council of

Interior Architecture) and CIDA (Council for Interior Design Accreditation) accreditation charters, the graduate interior architect/designer is foreign to the historical concepts. This is partly because of the verbal, rather than practical nature of the history courses. Usually students find these courses tiring and since the material is too dense to cover on several semesters, students are expected to memorize rather than internalize. After the completion of such courses usually students don't revisit the course material.

In order to improve the situation, students should be more involved with the historical design concepts. Research projects and creating presentation are one way to create involvement. However, in this time of so called digital natives, the usual process when preparing such assignments is copying and pasting information from the internet, without examining the content. This process misses the crucial involvement part. The interior architecture studio courses and other projects are very suitable for such endeavor. Typically a student completes at least 6 projects during interior architecture/design education, and often there are additional design projects in other courses. Although, the design problems in these courses focus on modem concepts, they can be modified to include or incorporate historical concepts. Such a parallel educational model should emphasize the importance of the historical knowledge and additionally utilizing the knowledge in actual solution of a design problem. This should concretize the historical knowledge of the student.

Today's design world is stuck with the inertia of the way things have always been done. As stated throughout this paper, the knowledge of the past illuminates contemporary design problems, and offer tested and perfected solutions. Even though many of today's interiors pose same problems that were already solved thousands of years ago, the previously said inertia diverts the designer from looking up for the solution. Sustainability is a powerful philosophy and given the course of current environmental problems, inevitably every aspect of human life is becoming sustainable. The aim should be not only sustaining the environment but also sustaining the culture and history.

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Aspects of Environmental Conflict Resolution and Consensus Building for Improved Sustainability Outcomes

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Abstract:

Seeking environmental sustainability requires a multidisciplinary approach (used by the Authors with science and law backgrounds). Consensus building is a transformational tool that can be effectively used to work towards achieving better environmental outcomes.
Consensus building is valuable in interest based negotiations and a primary mechanism for the negotiation of win-win agreements. Illustrations will be included in the paper.
This paper will emphasise that stakeholders should have early opportunities to participate in the making and amending of environmental policies.
<p>Techniques for the developing of consensus including publicly sharing information, using facilitated private and public forums, encouraging the use of dialogue rather than debate will be canvassed.
The future needs to include a greater use of techniques for environmental conflict resolution, dispute minimisation, consensus building and collaborative governance.
Why not have a dialogue rather than a debate? The difference is significant when looking at achieving good environmental outcomes. Collaboration is far better than polarised debate where issues can remain unresolved.
The right to participate is an important cornerstone in all public interest law and policy issues. There is an even greater need to develop this right in the context of encouraging a cultural shift towards greater consensual and collaborative environmental solutions.
By using facilitation and consensus building techniques and skills, public consultation becomes meaningful and interactive among stakeholders who become involved in the process and they "own" the process.
Developing options and active listening will be discussed.
Facilitated public and private forums are to be preferred. An independent unbiased private Facilitator helps manage the consensus building process.
The Environmental Law Roundtable of Australia and New Zealand (ELRANZ) model will be discussed as a consensus building approach - what is it and how it works?

Introduction

In the 21st century, we need to encourage a greater use of environmental conflict resolution (ECR), consensus building and collaborative governance techniques to avoid, minimize and resolve conflicts.

It is important to not only have a multidisciplinary approach to environmental issues but also have a number of skills available to deal with environmental science, agricultural engineering and development conflicts as and when they arise.

The ECR methodology toolkit should include third party facilitation, constructive dialogue and consensus building.

A Multidisciplinary Approach to achieving a consensus

Consensus building is about the transformation of a range of facts, circumstances and opinions into common ground among stakeholders who have started their discussions having opposing views.

Some stakeholders may view the issue in dispute from a limited interest based position. By discussing the multidisciplinary aspects of the disputed issue the limited interest based stakeholder has the opportunity to consider new options.

Moving towards a common ground position can benefit from a multidisciplinary exchange of ideas and solutions. This could include establishing an agreed list of priority actions with periodic reviews to see how well the solution is working.

Some environmental issues are so complex they need a multidisciplinary approach. This will generate new or improved ideas not previously thought possible. Some call this "thinking outside the square" or innovation. It certainly is creative new options by examining the environmental issue from different perspectives.

Which should come first – a change in public opinion or a change in environmental law or policy?

Historically, this question causes tension. Governments say they are there to govern. Non Government Organisations (NGOs) want to see Governments respond to public opinion.

Improving environmental conditions often require changing attitudes and/or behaviour. Embracing change is often a challenging exercise for Governments and/or the Community. Sharing information and ideas can help develop options for change, even by increments over time.

Changes which have the potential for improved sustainable outcomes should not be held back because of this question.

There is an important role for NGOs in helping achieve sustainability. Governments (no matter how good they are) do not have a monopoly on good ideas for sustainability. NGOs and Governments should collaborate or negotiate on goals and

implementation of sustainability policies and practices. With this "shared" responsibility it does not then matter where the idea originates.

A facilitated dialogue helps establish a sound participatory process.

The Right to Participate

The right to participate is an important cornerstone in any public interest law issue.[i] There is an even greater need to develop this right in the context of encouraging a cultural shift towards a greater consensual and collaborative development and environment system including dispute avoidance or resolution. All stakeholders need to be involved. It is not a "them and us" approach. We need to use methods which include all stakeholders no matter which part of the community they represent. The inclusive approach is built up over time and involves mutual sharing of information and trust.

Public consultation can be time and resource consuming. By using ECR (e.g. facilitation or negotiated rulemaking techniques and skills) the public consultation becomes meaningful and interactive among stakeholders who become involved in the process all along and they own the process.

The "early chance to be heard" proposal and the use of a "supervising facilitator" are designed to keep things moving through the development process by having meaningful conflict resolution processes available.[ii] There is a need to work to minimize the costs passed on to the community and to see how we can continue to strive to achieve good planning and environmental outcomes.

Dialogue rather than debate

Why not have a dialogue rather than a debate? The difference is significant when looking at achieving good environmental outcomes. Collaboration is far better than polarised debate where issues can remain unresolved.

Debates tend to entrench ideas and polarise opinions. It is a form of win/lose.

Environmental sustainability often benefits from a win/win solution (a negotiated outcome).

Compromise can be significant as the common ground will allow an environmental solution to be implemented without an expensive enforcement regime. An enforcement regime is more characteristic of a win/lose result which could be a Government decision to proceed with the idea which has won the debate.

A dialogue helps identify new and improved information from a variety of sources which will influence the final outcome. The sharing of information in a positive and constructive forum helps achieve a higher degree of understanding of other points of view and can more readily lead to a compromise. This approach is a form of consensus building by negotiation. The dialogue process is improved by the involvement of a third party independent Facilitator – by keeping the parties focused on the issues and keeping the process moving forward in a positive and respectful

manner.

Dispute Avoidance and Minimisation

ECR should also be involved in encouraging dispute avoidance and dispute minimisation. With better environmental knowledge there is an opportunity to avoid disputes. The community needs to focus on dispute avoidance as a mechanism. The Court system and its Alternative Dispute Resolution (ADR) cannot be expected to deal with all potential conflicts that are likely to arise if dispute avoidance does not become a reality. Disputes will not be eliminated completely. It is how we deal with conflict that can make a difference to the quality of the discourse.

Accessibility to all relevant knowledge is fundamental to any consideration of dispute avoidance. There is a need for trust so that all relevant information is recorded and available for public access. It is an essential part of the right to public participation that that participation is based upon the best information available. Otherwise a biased result occurs.

We all should trust the process which results in a publicly available ecoinformationbank.[iii] The bank holds environmental information gathered together as part of an environmental impact assessment or similar processes which is available for future reference. If we all have access to the same information then the level of disputation can reduce.

Where environmental factual disputes arise, limited enquiries or "fact finding assessments" can be undertaken which are aimed at resolving the dispute. The result is then recorded in the ecoinformationbank. Such a system can allow for amendments to be made when better scientific information becomes available. The right to public participation should be included in these processes.

Environmental guidelines or standards can be formulated based on the ecoinformationbank. Negotiated rulemaking techniques can be used to help formulate the guidelines.

Negotiated rulemaking is a process which brings together representatives of various interest groups and a government department or agency (including, if necessary, each of the different spheres of government) to negotiate the text of a proposed law (wide enough to cover new or amended legislation including delegated legislation).

It is important to emphasise that the type of participation needs to be meaningful otherwise sections of the public will come to distrust the process and then look for a confrontational approach. The methodologies will vary with the circumstances. The challenge is to work positively at the issues. Dispute avoidance will follow. Not all disputes will be avoided. However, by concentrating on trying to avoid disputes those that do arise will be limited in scope. If that does not work then ECR techniques (separate from or during the litigation process), properly used, will help to narrow or better define the scope of the dispute.

Public meetings or facilitated forums?

Polarised public meetings should be a thing of the past. They have a greater potential to result in increases conflict and a "them and us" approach, which makes a later ECR process more complicated.

Facilitated public and private forums are to be preferred. An independent private Facilitator helps manage the consensus building process. Working with the stakeholders (or most of them) before the forum is preferred.

A negotiated set of ground rules (before the forum begins) may include:

- All participants are on the same level in the hall and no one is on a stage or raised platform;
- The agency representatives are there to listen and not to lecture;
- Select beforehand two or three key speakers broadly represented of the different points of view in the conflict and from among the stakeholders to start the discussion process;
- Identifying the interest groups beforehand and discussing their concerns before the facilitated forum can help prepare the "draft agenda"; and
- Having those with common interests meet before the forum will assist in confirming the agenda. If stakeholders are consulted on what should be on the agenda a sense of ownership arises leading to less disruption at the forum.

There will always be something unexpected which arises at the forum so the Facilitator needs to have a flexible approach to be able to respond and keep the forum moving forward.

The Facilitator has to be unbiased but should have the opportunity to speak with the stakeholders before the forum. Those conversations are to remain confidential unless the participants agree for the information to be shared.

The advantage of confidentiality in separate sessions before and during the forum helps the stakeholders share details of their concerns and allows the concern (without the detail) being added to the "draft agenda".

During the forum separate sessions for groups with similar interests can assist with the development of options or help break deadlocks. More open discussion can occur in the separate sessions.

The Facilitator's role is wide and varied and includes negotiating a way forward. Confidential communications with stakeholders away from the open forum allows the Facilitator to have an understanding of the underlying concerns and suggesting options for the forum to consider.

Dialogue and discussions are forms of negotiation. Negotiations lead to agreements. Ideally agreements should be written and signed by all stakeholders. The written and signed agreement is not always practicable with a large group so electing a small representative group to write and sign a communiqué setting out the points of agreement from the forum is better than not having any document resulting from the forum.

All Stakeholders

Everyone who has an interest in the sustainability issue should have an opportunity to be heard.

Grouping stakeholders helps "people manage" the dialogue among all stakeholders. For example, where there are large numbers of stakeholders (groups and individuals) who have a broadly similar approach or interest, a separate preparatory forum could be arranged to discuss confidentially how this large number will be represented when all the stakeholders meet. This could include a consultation/discussion process and/or nomination of a few people to represent the group before the full stakeholder forum so common options can be discussed freely in the common interest subgroup without having the opposing stakeholders present.

For the dialogue sessions where consensus building is to occur it is essential to have all stakeholders represented. Having discussion with only some stakeholders has the tendency to end up with an agreement of limited value. Those not represented do not have any incentive to adopt the agreement as they have been denied their chance to be heard. The opportunity to participate is a key factor in establishing manageable and enforceable sustainability options.

How do you know you have identified all of the stakeholders? For example, you may start with 8 stakeholders. You ask each of those stakeholders to identify who else they think should be involved. In this way, people or organisations who may have been overlooked are included. Be flexible enough to add others who are identified later in the preparation phase and during the dialogue or forum.

Where the dialogue is an ongoing exercise other interested parties may be identified during the first open session and they should be invited to join the subsequent sessions.

Having all interested parties "in the tent" for the dialogue helps with the implementation of the results of the process.

The Independent Facilitator

This person can often be the key to success in negotiated forums. Stakeholders who are left on their own to manage a dialogue are too easily susceptible to having the dialogue turn into a polarised debate or worse.

The Facilitator's techniques allow for separate confidential sessions with some stakeholders to explore how the dialogue may move towards consensus without suggesting a solution. The role of the Facilitator here is one of "reality tester" rather than taking sides and advocating a particular solution. Remaining unbiased is paramount to keeping trust with all of the stakeholders.

Another form of early intervention is the Supervising Facilitator. By agreement it can be started as soon as the first sign of conflict arises. It can continue as required through the development process whatever form that system takes.

For example, the concept of a Supervising Facilitator should be considered for those development applications or proposals acknowledged as complex or those proposals that are expected to be long and drawn out during their assessment process. This may well be an ongoing appointment where the Facilitator comes in from time to time to help resolve conflicts when each arises and before the parties become entrenched or the issue becomes a stumbling block. With many aspects and fields of expertise there may be more than one occasion when a third-party neutral (the Supervising Facilitator) can help keep the assessment process moving.

An early and real chance for the public to be heard will reduce the number of disputes. Active listening helps. This includes the opportunity for the regulatory body and the proponent to actively listen to the concerns of stakeholders. Public participation is very important.

Many different tools are needed to be able to assist everyone, including Government, through the statutory maze. Third party neutral persons are essential for time and money reasons as well as for stakeholders' satisfaction. The concept of the Supervising Facilitator does not require legislative intervention. At present, it can be done by agreement. All that is needed is the willingness of all participants to work positively and proactively towards a genuine improvement in how we deal with the development process and environmental issues. It is recognized that a cultural shift is required, but that is not impossible to achieve. Statutory intervention may be necessary if the idea is not voluntarily taken up across a wide conflict spectrum.

Common ground can emerge from the separate sessions. As this occurs the Supervising Facilitator encourages the separate groups to share the information with the others. For example, after having been told confidentially that group A does not object to the proposed road widening the Facilitator hears group B say confidentially in a separate session they do not object to the road widening. The Supervising Facilitator could either encourage group A or B to add to the draft open joint session agenda something like "Who objects to the road widening?" or "Is there any objection to the road widening?" Alternatively, the Supervising Facilitator says to group B would it make a difference if group A did not object to the road widening? Assume the answer is "yes" the Facilitator encourages group B to agree to the Supervising Facilitator by asking group A the question to test out if there is agreement on this point. Once group A indicates agreement their permission is sought to communicate that position to group B (in other words remove the confidentiality). Alternatively, during the discussion of the agenda item in open session the common ground emerges from groups A and B stating their positions.

It is usual to start in open session with all parties present followed by the separate sessions. There can be more than one open session and more than one separate session during the course of the negotiation. Shuttle negotiations between separate groups during the separate sessions may proceed in stages. For example, the first open session is used for information exchange relevant to the conflict; followed by the first separate session where groups with common interest discuss their attitude the shared information; the second open session is used to ask for further information and state points of agreement so far; the next separate session allows each group to develop options on how to resolve the conflict with the Supervising Facilitator moving from

one separate group to the other groups to help with reality testing aspects of the options being developed; the third open session allows for a discussion of the options developed by the various groups leading to agreement.

There is no one for all method of proceeding through a negotiation. The dynamics depend on the nature of the conflict; the personalities of those involved; and how long ago the conflict started.

Improving environmental law and policy development and amendment: an Australian and New Zealand example

The Environmental Law Roundtable of Australia and New Zealand (ELRANZ) provides a forum for discussion and development of proposals for the harmonization or coordination of environmental law and policy throughout Australia and New Zealand. As a multidisciplinary forum, ELRANZ is open to professionals, Government Departments and Agencies, statutory corporations, business, industry, NGOs, academics and students.

The concept is capable of being adapted to other parts of the world. Regional groupings should be considered – eg, Asian Pacific Environmental Law Roundtable (APELR) connecting with the Asia Pacific Economic Co-operation (APEC) and G20ELR developing links to the G20 Summits.

As an inclusive and multidisciplinary approach to improving environmental laws and policies across Australia and New Zealand, ELRANZ advocates the processes of public participation and consensus building. Even before harmonization of laws and policies across all 10 jurisdictions in Australia and New Zealand, a greater level of cooperation will develop out of the ELRANZ process.

The Roundtable is a joint initiative of the National Environmental Law Association Limited (Australia) (NELA) and the Resource Management Law Association of New Zealand Inc (RMLA).[iv]

The ELRANZ offers opportunities for all spheres of government to have a forum where new ideas and improvements on old ideas can be discussed in a consensus building framework. ELRANZ expects suggestions to come from the public sector. The ELRANZ will allow Governments to engage with stakeholders through an independent forum.

ELRANZ is project oriented. In 2012 we are preparing for a dialogue on Oceans Policy in Australia where more than 100 pieces of legislation from 9 Parliamentary jurisdictions govern aspects of the Law of the Sea.

Facilitated interactive workshops will be used in a number of locations throughout Australia where consultation with the stakeholders will seek out common ground on how the laws could be harmonised across all 9 jurisdictions. The dialogues are currently expected to occur in six cities with an option to expand to other cities should funding sources become available.

Currently, ELRANZ is planning 3 rounds of dialogues followed by an interactive workshop session at the National Environmental Law Association of Australia conference in Melbourne in March 2013. The Authors will co-faciliate these dialogues.

The stakeholder groupings being considered deal with the following aspects of the Oceans:

- Conservation
- Fishing
- Oil and Gas
- Shipping
- Tourism

Principally peak bodies will be consulted along with representatives of the 9 Governments in Australia (one National, six States and two Territories). The identification of stakeholders is an ongoing exercise as preparations proceed.

The first round of dialogues will be aided by prior circulation of:

- A discussion paper setting out the current state of the law, policy and administration on Oceans.
- A draft Intergovernmental Agreement on how governments could move forward towards the harmonisation of the laws and policies relating to Oceans.
- A background paper which will include drafting instructions for a new Australian Oceans Commission Bill for the National Parliament.

After each round of dialogues there will be a circulation of a progress summary to all stakeholders of the progress made circulated. Intersessional email communications will keep the process moving forward.

Sharing information will be a key ingredient throughout the dialogue process. It will be a multidisciplinary exercise.

By March 2013 ELRANZ expects to have communique from stakeholders identifying the level of agreement on Oceans Law and Policy.

The United Nations Law of the Sea Convention took 10 years of international negotiations. The 20th anniversary of the coming into opertion of the UN Convention will be on 16 November 2014 acting as an important milestone to consider progress made under the Convention.

The ELRANZ Manual about some suggested processes

The ELRANZ Manual is a concise document describing the essential elements of the Roundtable and is available by emailing johnhaydon@ecodirections.com

The table of contents of the current ELRANZ Manual is:

- Foreword.
- Why ELRANZ?
- How to raise an issue for ELRANZ condisderation.
- What will ELRANZ do with your issue?

- Process Design.
- Sample Approach 1: The Blank Page approach encourages the regulatory authority to seek out public input early before a policy or law is considered for drafting, rather than holding back on public consultation until a discussion paper has been developed by the Government. The purpose of the blank page approach is to bring stakeholders into the policy creation process early. Building relationships of trust and cooperation are key components of public participation and consensus building. Common ground can be identified early in the process.
- Sample Approach 2: Discussion Paper. This approach is to draft a discussion paper with the identified interest groups and then to publish and distribute the paper, requesting feedback from interest groups and other important parties who may be identified after the paper is published.
- Sample Approach 3: Visioning is looking at a preferred future or a set of conditions to be realized over time. In this example the cross-section of stakeholders who are involved are predominantly residents. Visioning is said to mobilize citizen participation in political decision making. Community wide visioning also creates expectations amongst residents that similar consultation will be implemented in the future, and that certain actions will be taken.
- Sample Approach 4: Joint Fact Finding allows all parties to participate in identifying the issues, the experts, and the questions to ask the experts. This can be a very important means of resolving factual disputes that may arise if different interest groups have different experts with varying information on the issues at hand.
- Sample Approach 5: Best Use Information Technology is using available technologies to communicate with potential stakeholders as well as to disseminate information. This may seem simple, but the power of communication is exponentially increased with the use of the Internet. The possibility of harnessing this mechanism of communication for environmental regulation is tantalizing and should not be ignored.
- Members Only Information and Appendix A - Bibliography.

ELRANZ and Good Environmental Outcomes

Achieving good environmental outcomes requires the combination of a number of different efforts. These efforts are integrated within an ecological sustainability discourse. Setting broad policy and law frameworks is part of the process. ELRANZ promotes greater stakeholder involvement, through consensus building and public participation, in making improvements in environmental law and policy in Australia and New Zealand. There is a need to raise awareness of best practice facilitation, creative visioning, meaningful stakeholder participation and other consensus building techniques.[v]

Consensus building and public participation can transform the traditional adversarial forum of dispute resolution into a forum characterized by collaboration and cooperation. These approaches (techniques) are relevant to dispute avoidance, minimisation and resolution. ELRANZ recognizes that the adversarial tone of litigation (and cultures of adversarialism) can undermine the more cooperative spirit

of consensus building, so all stakeholders must be strongly committed to achieve this goal.

The Roundtable includes the following concepts:

1. Corporations, associations, organizations and individuals can register as ELRANZ Associates and initiate roundtable issues;
2. Project Teams are established to assist in ELRANZ projects;
3. Associates may engage in research, consultation and brainstorming with respect to a project on the ELRANZ agenda and actively participate in neutral third party facilitated conferences, seminars and meetings;
4. Suggested projects will be prioritized within the ELRANZ agenda. The results may include draft legislation, a new policy approach or a protocol for industry;
5. Issues suitable for resolution through consensus building processes may be recommended to the Australian and New Zealand Judicial and Intergovernmental Ministerial meetings;
6. Some ELRANZ projects could be managed through adaptations to the negotiated rulemaking process; and
7. Seminars, public forums and other educational activities can be included as Roundtable events to ensure the involvement of individual and corporate NELA and RMLA members as well as to continue building support for the growing network of ELRANZ Associates.

Conclusions

Sustainability is about developing different options to gain improved environmental outcomes.

The challenge is to continually improve and adapt the "methodology toolkit" to achieve a greater level of environmental sustainability.

There are advantages in having a multi disciplinary approach to sustainability which work towards achieving better environmental outcomes not only for the current generation but for future generations (using the intergenerational equity principle from the Rio Declaration).

Consensus building across all community interests (stakeholders) improves the prospects for sustainability.

Public participation leads to improved decision making because a wider cross section of information is available to the ultimate decision taker.

Independent Facilitators are an important component for sustainability discussions because they help manage the dialogue process in a positive way leading to the generation of options which may not have otherwise have been discussed.

[i] J. Haydon, *The Continuing Development of the Right to Know and the Right to Participate as Public Environmental Rights* presented to the Queensland Environmental Law Association Inc (QELA) conference (1995).

[ii] Both developed through EcoDirections International Pty Ltd in 2003 for the early chance to be heard (Dr Kuang and John Haydon) and in 2004 the supervising facilitator concept (John Haydon).
[iii] Ibid at 1.
[iv] The Environmental Law Roundtable concept was created by John Haydon who is now the Convenor.
[v] Eg, J Haydon & G Ayriss *ELRANZ: Legal Issues in Consensus Building* April 2006 RMJ 36 (Resource Management Journal of RMLA NZ); J Haydon & S Sellwood *ELRANZ: Designing a Consensus Building Process* August 2006 RMJ 33; and J Haydon & G Ayriss *ELRANZ: Environmental Conflict Assessment* November 2006 RMJ 38.

The Experiences of Family Support by People in Recovery from Drug Addiction

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Abstract:

Recovery from drug addiction is a life-long process. The aim of this preliminary study is looking at the experiences of family support by people in recovery from drug addiction. This study employs a qualitative format using semi-structured interviews with four recovering drug users. Several themes were identified and discussed in relation to the literature on family support of people in recovery. The results highlight the importance of family support in the recovery of drug addiction. Suggestions and recommendations are also included.

1. Introduction

All over the world, drug abuse has become a huge problem and is among the most pressing health issue. There is no one country or community that has been spared from this scourge. The dramatic increase in drug production and trafficking in recent years has caused a growing number of drug users worldwide. Like other countries in the world, Malaysia is no exception in facing the challenge of overcoming the problem of drug addiction. Due to its seriousness, the country has made the call to society to view drug as the 'nation's number one enemy' and has implemented a multifaceted anti-drug strategy that includes law enforcement, preventive education, treatment and rehabilitation (Scorzelli, 1992).

Drug users or drug dependents are usually perceived as loners or people cut off from primary relationships. However, studies have shown that 60% to 80% of people who are drug dependent, especially those below the age of 35 either live with their parents or are in daily contact with at least one parent; and 80% to 95% are in at least weekly contact (Bekir, McLellan, Childress, & Gariti, 1993; Cervantes, Sorensen, Wermuth, Fernandez, & Menicucci, 1988; Stanton, 1982, 1997). This applies to both genders, male and female. In the context of Malaysia, where the culture is more collectivistic, drug users usually maintain their connection with their families. This has obvious implications for treatment. Terrell (1993) and Bowser & Word (1993) stated that nuclear and extended families are untapped resources in treatment and prevention of substance addiction. According to Cervantes et al. (1988), drug addicts have, in fact, family ties. Thus, they are likely to benefit from a family systems approach to substance abuse treatment. They suggested that for professionals coping with clients' addictive behaviors it may be wise to consider family ties when planning treatment.

There can be a number of factors related to the family that may influence the addictive process and its remediation. First, the onset of drug abuse and its overdoses may be precipitated by family disruptions, stresses and losses (Duncan, 1978; Krueger, 1981). There may also be modeling on part of the parents of drug or substance-taking behavior (Gorsuch & Butler, 1976). Kaufman (1985) and Stanton (1982), mentioned about preserving the family's homeostasis while Craig (1993) stated about other family members that can engage in enabling behaviors that perpetuate the substance abuse of a particular family member. In many cases, an addicted woman who is a mother will see her children as the most meaningful part of her life and the strongest motivation she has to get off drugs (Eldred, Grier, & Berliner, 1974; Noorhayati Awang, 1997). Based on these factors, it can be concluded that there is need to address family issues in a comprehensive treatment program.

Families can be of support for addicts in treatment and in maintaining recovery. Various studies have shown that there have been many factors contributed towards relapse among drug addicts. These factors include psychological, self-efficacy and lack of family and community support (Moos, 2007; Fauziah and Naresh Kumar, 2009a; Fauziah and Naresh Kumar, 2009b Allsop et al., 2000; Ellist et al., 2004; Salmon et al., 2000).Weak support among family members and the community of former addicts may result in a higher tendency to relapse (Daley, 1987; Hawkins & Fraser, 1987; Miller, 1992; Zackon, McAuliffe & Ch 'ien, 1985). Indeed family support is needed to ensure the treatment is successful and relapse can be prevented. Isolating recovering drug dependents will only frustrate the treatment process resulting them back into the realm of addiction (Daley & Marlatt, 1992; Vicary & Lerner, 1986).

Thus, the aim of this study was to explore the experiences of family support by people in the recovery from drug addiction. By developing a better understanding of these people, families, counselors, and those involved in providing services to the drug users and their families may gain information that will make the integration of the family component into their treatment and

prevention models more successful. Because people in recovery's experiences can be viewed as a complex occurrence, a qualitative approach was adopted to serve as the method of this study.

2. Method

Participants

Four participants who are recovering from drug dependency were selected from one drug rehabilitation centre. All four of them are adult males, aged 35, 37, 40 and 48 respectively. All of them had also experienced relapse. They all consented to their participation in this study.

Researcher as instrument

The role of the researcher is critical in qualitative methodology because the researcher identifies the process of the phenomenon to be studied, constructs the research question for the scientific inquiry, performs primary data collection and analysis procedures and synthesizes the data into confirmable results (Strauss & Corbin, 1998).

In qualitative research, the researcher is the instrument. The researcher is responsible for deciding what to explore and analyze during the data collection and analysis procedures. The researchers' educational and professional background will be a useful perspective to lend to this research.

Data collection and analysis

Data was collected from the participants at a drug rehabilitation centre until data is saturated to ensure the depthness of the data using semi-structured interview. All the interviews were audio-recorded. Data collection procedures include:

(a) initial individual interviews

(b) document reviews

(d) two rounds of follow-up interviews

To ensure trustworthiness, dependability and credibility of the data, specific strategies for triangulation has been employed using reflective journaling and member checks.

Data was then analysed using content analysis of the interview transcriptions and documents. Miles and Huberman (1994) outlined three types of analytical tasks in qualitative data analysis: (a) data reduction, (b) data display, and (c) conclusion drawing and verification. Themes, as they emerged, were identified. Once themes are identified from participants' responses, initial categories will be identified and questions will be formulated to narrow the focus of the study, confirm initial findings and probe for new or additional information.

3. Results

Four themes emerged from the data analysis as follows: (a) gaining acceptance, (b) accepting advice and guidance, (c) family's commitment, and (d) sensing hope.

(a) Gaining acceptance

Gaining family acceptance is important in order to preventing relapse. From the data collected, there were statements that show to us the acceptance given by the respondent's family. Acceptance is one of the important elements that family should do for the former addicts to change. Basically, family should accept each other whether they are problematic

person or not. In part, acceptance in family will indirectly change the perception and the person will think over the problem again. The acceptance in the family will lead them to think all over again and want to change. According to Hall, Wasserman & Havasay (1991), one factor of relapsed occurs is because of the social factor be it society's acceptance or weak social support network from the surrounding.

(b) *Accepting advice and guidance*

Respondents stated that the family members also provided advices and guidance to lead and create awareness in them. There is several statements detected show the advices given by the family. As Fauziah & Naresh (2009) has pointed, 59% respondents agreed to say that their family members who are facing with problems would come up to them to get advice. While 60% respondents agreed to say that their family members would come up to them to get emotional and spiritual support. According Thessaloniki, 2009, a member of family (usually the mother) try to find the solution alone with many ways (doctors, lawyers, priests or psychologists, etc.) or try to press drug-addicted person. Advice is one of the elements that can lead us to the right way. Normally, the drug addicts will refuse to get the advices from the family or other people and likely to talk back and found so much reasons to protect or defend them. So, the family members should take the right or proper way to give an advice in order to make the addicts aware the meaning of the advices. The three factors that should be considered before giving an advice are 1) not letting down the person who will receive the advice; 2) the time is suitable to give advice; and 3)understand the situation of the person who will receive advice.

(c) *Family's commitment*

From the interviews, researcher had detected several statements that show the commitment given by the family. Despite the commitment given by the family, there is also respondent's commitment towards the family. This respondent has responsibilities and commitment towards the family and he is like the financial sources for the family. According to this respondent, he stated that he is the only who one is working in the family. A studies supported this finding, conducted by Brook, Whiteman & Gordon (2002), shows that problematic families showed positive relationship with drug usage. It is because the dependency more or less pressured the former addicts because they have to shoulder their family's problems and in the end, caused them to lose control and to seek easy way out by turning to addictions. Because of that, family should be responsible in playing their important role in helping former addicts to lead a life that is free of drugs.

(d) *Sensing hope*

Recovering addict always seeks and sensing hopes to fully recover from their addictions. In order to sense the hope to recover, family support plays an important roles during this phase. Respondent had stated the statements that demonstrate the support received. Various studies have shown that support from family is importance to the drug addicts. Hence, to ensure successful recovery, it is recommended that family members and significant others participate in the addicts recovery process. From researcher views, sensing the hope for support is important as acceptance. Former addicts need supports from the family and surrounding for not returning to drugs. Without support, the former addicts might have the attention to relapse because of they have lower self esteem and self confident. Support is like the device in other to maintaining recovery among the former addict and support from significant person is needed.

4. Discussion

Family has an important role in attracting their addicted family member into treatment and fostering supportive environmental change during recovery. Family involvement can also foster better engagement of addicted individuals in treatment because based on the above finding; commitment shown by family members is regarded as support by the person in recovery.

In a study by Fauziah & Naresh (2009a), lack of open interaction between recovering addicts with their family members increases the tendency to relapse amongst the addicts. 57% of the respondents admitted that they would feel uneasy and find it difficult to express their problems with family members. Although this was also mentioned by participants in this study, they stated that by feeling the hope that their family members have for them this encourages them to try being more open especially to accept the advice and guidance given by their families. However, they admitted that if left prolonged, this situation would be able to cause stress to the recovering addicts and may lead to many difficult situations. According to Mohd Taib and Mohd Khairi, (2000), among the causes that create uneasiness amongst drug users to talk to the family are lack of communication and ineffective interaction amongst family members.

Furthermore, Lasimon Matokrem (2007) in his writing on the principles of effective treatment and recovery highlighted the importance of focusing on re-establishing recovering addicts' relationship with family, personal development, career, social activities as well as healthy lifestyle. Hence, to ensure successful recovery, it is recommended that family members and significant others participate in the addicts recovery process. This indicates that prevention of relapse to drug use required an inclusive social support and probably has significant effects on relapse after being released from rehabilitation (Elliset al., 2004).

A new study published in Behavior Therapy apparently confirms that offering 'understanding and encouragement' to those with drinking and drug use problems is the best approach family members can take in dealing with the situation. In addition, a study conducted by Fals-Stewart (2001) found that men recovering from substance abuse are less successful if they believe their spouse or partner is critical of them, rather than supportive.

Hence, Thomas (1992) stresses that a stable and strong family must not only care about the welfare of the family, but it also must function to guide the growth of the family members. This means that every family member should have a high and continuous commitment towards all the family members. The commitment could be observed by the family members' serious effort to spend time and energy for activities that involved the family affairs and well-being. The activities that can generate the familial spirit are such as solving family problems, taking over family member's responsibility if the situation needs it, or doing activities together like cleaning the house, having dinner, or going for picnics (Lily Mastura Harun, 2006).

5. Suggestion and Recommendation

This study has important implications to families, policy makers as well as those providing prevention, treatment and rehabilitation programs in understanding the issues of integrating the family as a support into practice.

Embedding Families in Treatment and Rehabilitation Programs

Prevention, treatment and rehabilitation programs should establish more activities with the family. By increasing the commitment and support from the family towards the recovering addicts it will indirectly lead to recover. Respondents stated that they really need support from their family in

order to recover from being drug user. Implication of if family is not addressed in a rehabilitation and prevention program is that those involved will miss an opportunity to explore a system might influence their work with people in treatment and recovery and they will thus, diminish their potential to make a difference in their client's life.

Enhancing Counselor's Competency

Counselor is one of the important characters that can lead to prevent relapse. Drug users look down to counselor due to the labelling that counselor's are not competent to treat addictions. According Abd Halim (2008) counselors must have some characteristics and necessities to be a better person and its can be list as below:

1. Education necessity – they must have some training and education at least first degree until doctorate level or PhD in human services.
2. Training, qualification and experience – as a counselor they must have at least three year of experiences in addiction counseling and have knowledge in term of basic and application in addiction counseling. The professional qualification are needed and supposed to be having it.
3. Ideal personal characteristic – must have very good professional consideration, unconditional positive regard, and use confrontation in helping process rather than giving punishment and being prepared to any situation of client.
4. Role as an addiction counselor – helping, teaching, encouraging and guide in recovery process. They are also must being prepared with knowledge's.

From the characteristic listed above, it shows that addiction counselor needs to improve themselves in other be a competent addictions counselor. Sometimes, the drug user needs someone to lead them to the right way and get support to do it. So, counsellors together with families can help and support them to do the right thing and aware them about the dangerousness.

Media Campaign

Media plays important roles to burst out campaign on promoting families support towards increasing recovering addicts. As we can see nowadays, there are lots of media campaign that promoting the negative effect of drugs. Anonymous (2003) in his study on anti-drug campaign conducted by Leo Burnett and McCann-Erickson in 2002, found that the media campaign can have both positive and negative effects on the target group. The findings showed that only 25% of the respondents have a tendency to drug addiction after watching the anti-drug campaign and 75% of respondents more likely to avoid drugs. It is useful to make people aware of the consequences of taking drug, but it indirectly influences the society's view towards the drug users. Media should always promote the important of families as part of prevention, treatment and rehabilitation elements.

Conclusion

The results highlight the feasibility of utilizing the family as a source of support in the treatment and recovery of drug dependents. Family support plays an important role and is the most significant contributing factor to the positive outcome of recovery amongst recovering addicts. Thus, all treatment facilities must address the element of family support in the modality of treatment and rehabilitation.

Future research using quantitative methods would be useful in providing more information on a represented sample and an in-depth exploration of families' using appropriate inventories

investigating coping issues as well as providing support to recovering drug addicts is recommended.

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Solar Home System Evaluation in Bangladesh

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Abstract:

This paper will present our ongoing research about the present and future evaluation of SHS (Solar home system) in Bangladesh. It will describe the possible future threats and present limitations of SHS in our country. In this paper, we have divided our discussion into two parts. In our first part we have made an overview at the present condition according to the data of IDCOL and our field level survey. We have discussed about the working process of our companies (Partner Organization) like Grameen Shakti (GS), BRAC which are related with the SHS. We have also discussed about the development impact of SHS in our country. At the end we have made list of present limitations and some situations which can be a huge environmental issue in the near future.
In our second part, we have discussed about our ongoing research areas, the process we are following for the research and the categories of question we are going to ask in our field level survey. It will also explain how our ongoing research searching for the solution of existing problems and what should be the planning for the future threats of SHS in Bangladesh.

I. *INTRODUCTION*

Bangladesh is in the 8th position among the most densely populated countries in the world [1]. Approximately 79% of the total population 161,083,804 (July 2012 est. [1]) — are living in rural areas. Though our territory is full of human resources but the electrical energy consumption is only about 140 KWh which is one of the lowest power consuming countries in the world. Despite the fact that we are in a heavily populated country, it is unfortunate that, the maximum of our people do not have the privileges of using electricity. For a developing country like Bangladesh, it is practically unfeasible to electrify all the residences through the extension of distribution grids. At this point, the renewable energy could be an effective solution against this scarcity of Electricity in Bangladesh [2] [3].

The main energy sources of Bangladesh are Biomass and Natural gas. Over 80% of people depend on traditional energy sources such as firewood, cow dung and agricultural residues for their energy needs [3]. Excessive use of firewood's threatens the remaining forest cover, which is only 10% of the total land area of Bangladesh (WEC, 2000). So the proper utilization of solar energy is the most Eco friendly and environment saving plan for us. Sunlight is combined with two types of energy i.e light and heat energy. Both may be utilized directly or indirectly by converting them into electricity. Being a tropical country which receives sunlight throughout the year, there are a lot of possibilities to be benefited by confirming the appropriate use of this energy. Not only that but also there are proposals of supplying solar electricity through the normal grid [4].

According to recent data, the economy of Bangladesh is growing up and the rate of poverty is falling gradually. If we figure out numerical data which indicates that economy has grown at around 6% or more and poverty has fallen substantially from 45% in 2005 to around 30 by 2010[3,4].The general lack of access to electricity imposes limits on the prospects of growth and increased welfare. This lack of electricity is also opposing our process of digitalizeing the nation. To increase such condition and generation of electricity we can realize the importance of solar home system (SHS).

II. *PRESENT CONDITION OF SHS IN BANGLADESH*

A. AN OVERVIEW

The project of Solar Home Systems (abbreviated SHS) is being run by a financial institution which was established by the Government of Bangladesh Infrastructure Development Company Limited (IDCOL) in the year of ****. It had been installing the SHS since 1997 but the real growth started from 2002 and at present in every month around 60 thousand SHS are being installed[5].It actually promotes the dissemination of SHS in the remote areas of Bangladesh with the help of World Bank, Global Environment facility, GTZ and KFW. Up to August 2010, a total of 645,033 SHSs have already been installed under this program. Their target is to finance 1 million SHSs by the end of 2012. IDCOL is presently implementing their program through 30 partner organizations (POs).

According to the 31st August, 2011 data, IDCOL installed 1,073,872 SHSs [5]. So the number of installing SHSs is increasing enormously day by day. It also means that using SHSs especially in remote area is also increasing with a satisfactory rate.

Table 1: Division wise installation of SHSs (source: IDCOL data) [5]

NAME OF DIVISIONS IN BANGLADESH	NUMBER OF INSTALLATION
DHAKA	2,76,681
CHITTAGONG	2,11,381
BARISHAL	1,98,337
KHULNA	1,21,753
RAJSHAHI	1,51,091
SYLHET	1,14,629

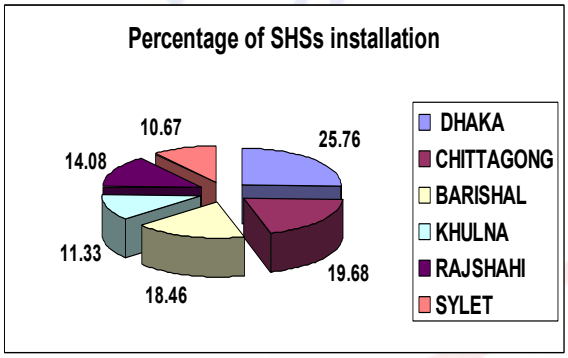

Fig 1: Solar home system installation Data

From this chart we can see that the percentage of installing SHSs is high in the Dhaka Division which is about 25.76 % (According to the data of August, 2011) [5] [6].After that, Chittagong is 19.68%. Till that the installation of SHSs is higher in Dhaka, Chittagong and Barisal than other divisions of Bangladesh, we can say that the plan of developing remote areas through SHSs is not yet so much successful. But it is increasing and we can expect proper rural development in the near future. The following figure shows the expansion of usage of solar home system in Bangladesh.

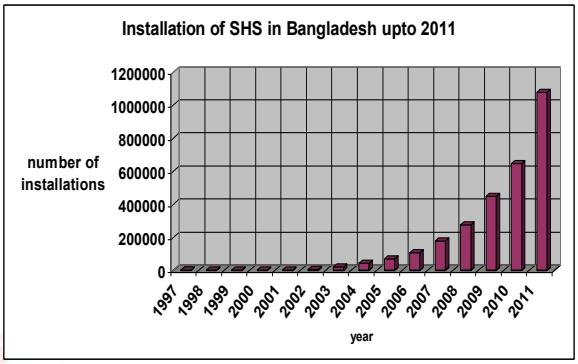

Fig. 2: Total solar home system installation in Bangladesh (Source: IDCOL data)

B. COMPANIES

As we said before there are about 30 companies in Bangladesh which are working for the progress of SHS under the regulation of IDCOL [5]. Those companies are called POs (Partner Organization). IDCOL also conduct the training program for the stuffs of those companies to build the awareness. Top SHS companies are:

- Grameen Shakti
- RSF (Rural service foundation)
- BRAC foundation
- Srizony Bangladesh
- And some other companies like Hilful Fuzul, COAST trust, DESHA, AVA (Association for village advancement) etc whom are not still up to the mark.

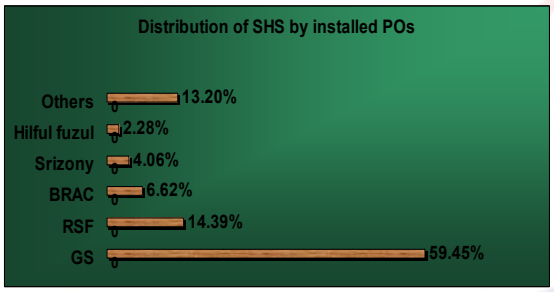

Fig 3: Distribution of SHS in percentage
(Source: IDCOL Data)

Grameen Shakti (GS) is the largest SHS Company in our country. About 59% of total installation was done by GS. According to the data of August 2011 - 6, 38,502 SHSs has been installed by GS. They are the fastest growing SHS Company in our country. Their installing rate is increasing exponentially with a plan to reach 1 million installations by 2015. They have four different schemes to provide SHS to their customers. They also have very much disciplined process to promote SHS in the rural area [6].

RSF (Rural service foundation) is the 2nd largest company which is also contributing for the installation of SHSs in Bangladesh. Till now about 1,54,608 SHSs have been installed by RSF which is 14.39% of the total installations. It has about 455 unit offices under the regulation of IDCOL. At present, to facilitate lower income group, RSF has designed the small SHS (16 Wp and 21 Wp) with low power LED lighting devices. Initially 200 small SHSs have been installed under the pilot program and finally 700 have been installed. Main targeted users of that mini system are small grocery shop, small home business where no electricity is observed [5,6].

BRAC is one of the largest NGOs in the world and it is also working for environmental issues for the long time. BRAC solar enterprise started its journey towards rural electrification through SHS in 1998, in collaboration with IDCOL. Till now BRAC foundation installed about 71,150 SHSs which is 6.62% of the total installations. The facilities of BRAC Foundation, consisting of 260 unit offices, 59 districts office and 30 technical centers throughout the country, are used to manage and follow up the clients of the solar loans and solar systems. BRAC used to provide down payment which is 15% of the total cost and the time duration is 1 to 3 years with the interest of 12.5%. BRAC is currently working on a pilot program with GTZ, consisting of 425 SHS aimed at the poorest household. Again a lot of students from BRAC University are working for the development of various implementations of SHS with the help of BRAC foundation [7].

Srizony is the 4th largest organization that is working for installing SHS. Till now 43,663 SHSs have been installed by them. Srizony has been installing SHS since 2002 by the technical & financial support of IDCOL [8].

III. *DEVELOPING IMPACT OF SHS*

As we said before that installations of SHS are growing exponentially upward in our country. As a consequence, we are experiencing the both:

- Positive impacts &
- Negative impacts.

We can figure out a lot of changes that have come in remote areas by using SHS. Moreover the notion of people is gradually changing by using of SHS both in household and rural business side. Actually the modules that are offered to households and other entities include scopes for lighting and running of a black and white TV which are also helpful in small grocery business. There are some positive impacts of SHS:

- The replacement of the kerosene lamp would lessen indoor pollution and thus be good for health in general and more probably for women.
- The new system will immediately extend the working hour in the evening.
- Better lighting facility may provide more study time for students.
- Longer hours during the evening may alter the time use pattern of both men and women.
- Another benefit is charging mobile phones which are now immensely important thing for the villagers.

Actually now rural people are experiencing more contented using SHS than before. Though our remote part is heading towards the development with the help of SHSs, a lot of threats are also paralleling them. There are some existing negative impacts or limitations and future threats:

- The SHS is composed of several inter locking components. Unless this are well configured to work with the other components, it may not provide optimum service.
- Many technical and organizational shortcomings are facing during the implementation at the grassroots level.
- At the bottom end of the organization tree, there is a need for further technical training of the field operatives. For effective maintenance and the operation of the SHS, the field offices need good equipments and testing facilities.
- According to our ongoing research we come to know that the quality of the components in recent installation worsened from the initial installation.
- SHS avoids the use of fossil fuels for generation of electricity. So it reduces the use of carbon. Along with the apparent carbon related benefit, one should also look at other environmental faults such as those caused by batteries used in the SHS and this is the largest future threat of SHS.

  As our number of installing SHS is growing upward day by day, the numbers of using batteries are also growing highly. In the other view the numbers of damage batteries are rising. If we do not have the process of recycling SHS batteries in an immense number then we will face a big environmental hazard in future.

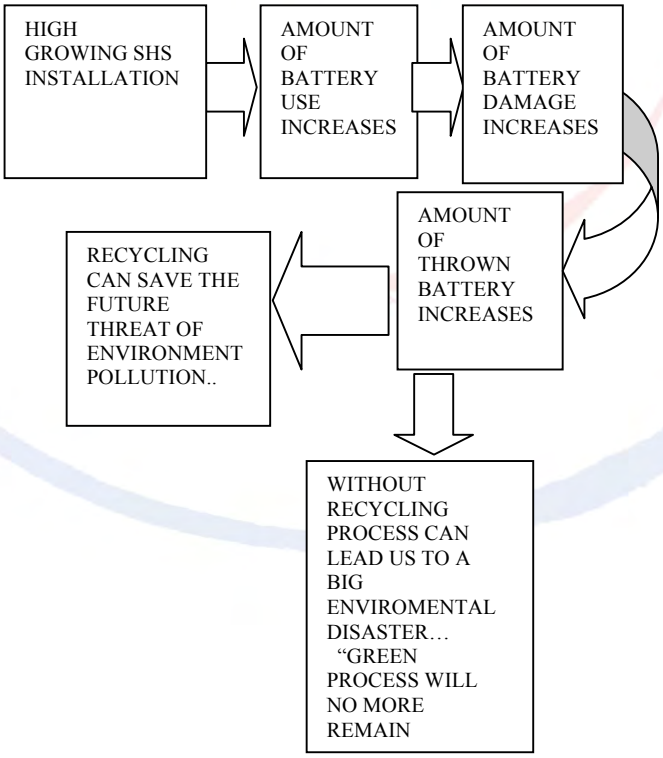

Fig.4: Future threat of SHS. (Source: Authors)

IV. *Our Ongoing Research*

As we discussed before, the rate of using SHS has increased in a gigantic number. By looking at our present energy crisis situation we can assume that the number of using SHS will increase more exponentially in future than before. But is it really true or the fact will be beyond our assumptions? Can SHS survive in the long run of energy crisis? How efficiently it can match our future energy needs? Keeping those future questions in our head we have started our research to find the answer.

A. Objective

One of the major objectives of our study is to find the solution of the future threats of SHS. Again in our field level study we are trying to explore more limitations that are creating now and have a huge possibility of occurrence in near future. Our aim is to find the proper possible solution of those limitations so that SHS can serve efficiently in future. Keeping the illiteracy rate of the remote areas in our mind, we are searching for efficient and easier technical solution which can easily get close to the heart of those people.

B. Analysis Method

We have divided our survey into two parts.

- Company survey.
- Field level survey.

In terms of company survey we are trying to get the data like:

- Data of the most recent installation & what are the conditions of SHS which have already been installed.
- Identify whether they have delivered the expected benefits to the subscribers or not.
- Identify their future plan and goal
- Their consciousness about the existing limitations and the frequency of solving the problems.
- About the technical efficiency of their field level stuffs and overall after installation process.
- Their concept about battery recycling.

In terms of field level survey we are searching for

- People's comfortable level of getting SHS installation
- Benefits they are getting from the company.
- Future of SHS according to them
- Their concept of getting better
- The real benefits they are getting from the SHS installation

We conducted our research on 6 top most SHS companies and about 95 families who have already installed SHS in their individual houses. Among the 95 families 38 of them are running their own small business using the benefits of SHS.

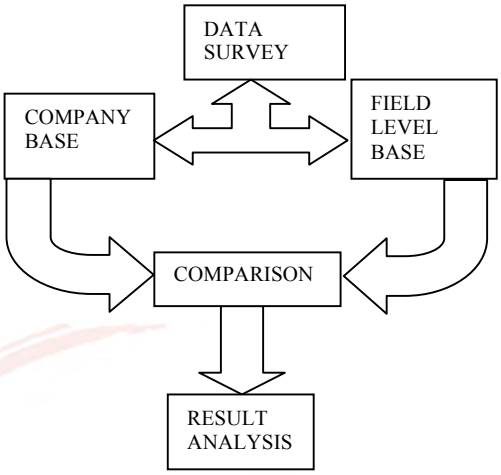

Fig 4. Analysis Method

Table 2: Category of Questions:

	Category of Question	Number of Questions
TO POs	1.ABOUT SHS	3
	2.BENEFITS GIVEN	2
	3.PRESENT PROBLEMS	2
	4.ABOUT FUTURE PLAN	1
	5.RECYCLING BATTERIES	2
TO PEOPLE	1.ABOUT SHS	3
	2.BENIFITS TAKEN	2
	3. FACING PROBLEMS	3
	4. ABOUT DAMAGE BATTERY	2
	5.FUTURE OF SHS	2
	TOTAL	22

C. Some Of Our Result Analysis

At the first stage of our survey we have discussed about the kerosene and SHS among 95 families. In our remote areas kerosene is still in the dominating mode in spite of having a lot of environmental disadvantages.

Table 3: User Types

Types	Number of Families
Kerosene (Natural Fuel)	49(most rural part)
SHS	28
National grid	18

Actually this is the average scenario of a particular area which basically represents the overall condition of whole Bangladesh. But we can find the actual reason behind the percentage of usage. We asked about the problems of using SHS to those 49 families who were using Kerosene as their daily energy consuming system instead of Electricity.

Table 4: Causes of not getting SHS (Among 49 families) (Source: Investigation by Authors)

No. of people	why
30	Lack of money
22	Do not know how to use
16	Kerosene is ok!!

N:B: this survey was conducted among 68 people of 49 families.

Though BRAC Foundation and Grameen Shakti have their own financial model to serve SHS to poor people, still there are lots of families who do not have dare to take SHS. When we asked them about installing SHS, they told that they did not have enough money. It certainly indicates that they do not know about the installing credit scheme program and BRAC foundation down payment system which are only for these underprivileged people. So it specifies the promotion limitation of POs. So our SHS Company should be careful about their promotion program. It should be practically effective so that the poor people can really get the benefits of SHS.
Including 28 families who installed SHS program (in figure5), we also asked another 45 people (Total 45+68 =113 people) about the satisfactory level of SHS. According to their answer:

Table 5. Survey analysis.

NO.OF REOPLE	ANSWER	CAUSE
53	SATISFIED	
30	NOT SATISFIED	TECHNICAL PROBLEMS
5	NOT SATISFIED	STUFFS ARE NOT AVAILABLE IN NEED
7	NOT SATISFIED	ONLY LOW POWER DEVICES CAN BE OPERATED.
5	NOT SATISFIED	BATTERY PROBLEM
13	NOT SATISFIED	HIGH INSTALLATION PRICE

These are some of our field level result analysis. We are still doing our survey on different company's data. One of our main focuses is Battery recycling plan of those company.

V. *Conclusion*

To match the growing demand of SHS installation it should be more efficient so that public (especially people from remote area) can feel the importance of it. We hope in near future rural people will be habituated with using SHS. Our ongoing research is finding the solution of existing and future threats of SHS. We think our data will be very much helpful for SHS companies and installer to become more efficient.

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Wastewater Treatment Bioprocesses: Modeling Issues And Simulation

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Abstract:

Human impact on the environment is beyond pollution, the term being more comprehensive than environmental deterioration. The environmental deterioration means the alteration of physical, chemical and structural components of the natural environment, reducing biological diversity and productivity of natural and anthropogenic ecosystems, ecological balance and impaired quality of life caused mainly by water pollution, air and soil pollution, overexploitation of natural resources, and by poor management and recovery.

In the context of environmental protection, the implementation of wastewater treatment bioprocesses, especially of biotechnological processes used for wastewater and organic waste treatment becomes a necessity. Superior performance regarding the exploitation of such processes can only be obtained by applying modern techniques, both in terms of proper technologies and methods of modeling, identification and control.

From a systemic point of view, biotechnological processes and the wastewater treatment ones in particular have a highly nonlinear character. The bioprocesses' modeling is a very difficult task: these systems contain live microorganisms and therefore their operation and growth dynamics in particular, are often difficult to understand, highly nonlinear and nonstationary.

In this paper, modeling issues concerning some biotechnological processes used for wastewater treatment are discussed. Two approaches are widely analyzed and compared: the classical modeling and the so-called pseudo bond graph method. These techniques are applied for the modeling of wastewater treatment processes. The dynamical models are obtained and several simulations are conducted by using 20sim and Matlab modeling and simulation environments.

1. Introduction

Human impact on the environment is beyond pollution, the term being more comprehensive than environmental deterioration. The environmental deterioration means the alteration of physical, chemical and structural components of the natural environment, reducing biological diversity and productivity of natural and anthropogenic ecosystems, ecological balance and impaired quality of life caused mainly by water pollution, air and soil pollution, overexploitation of natural resources, and by poor management and recovery [1]. Any substance (chemical, biological) solid, liquid, gaseous or vapor or any form of energy generated by human activities that alters the equilibrium of its constituents and bodies lives causing damaging property when introduced into the environment, represents a pollutant.

Each main sector of polluted environment is not independent, but as it is known among the various compartments of the ecosphere has permanent transfers of matter and energy with other sectors. Despite active measures for waste disposal, the most important substances with direct effect on water pollution are chemicals (chlorides, pesticides, oil, gas, heavy metals, and organic substances) and biological factors (pathogens, parasites, etc.) [2], [3]. For accurate measures of pollution control and environmental remediation, environmental monitoring systems were implemented based on process control. These systems aim to optimize the industrial processes for better efficiency and lower pollutant emissions. Together with surveillance, forecasting, warning and intervention systems that take into account the evaluation of the dynamics of quality characteristics of environmental factors, these measures can offer reliable and improved results for environment preservation [4].

In the context of environmental protection, the implementation of biotechnological processes used for wastewater treatment becomes a necessity. Superior performance regarding the exploitation of such processes can only be obtained by applying modern techniques, both in terms of proper technologies and methods of modeling, identification and control. From a systemic point of view, biotechnological processes and the wastewater treatment ones in particular have a highly nonlinear character. The bioprocesses' modeling is a very difficult task: these systems contain live microorganisms and therefore their operation and growth dynamics in particular, are often difficult to understand, highly nonlinear and nonstationary.

The most common biological wastewater treatment is based on the so-called activated sludge process [5], [6]. The classical modeling method for bioprocesses can be found in several papers and industrial applications [7], [8], [9]. The modeling of wastewater treatment bioprocesses followed this classical line, and a lot of useful examples can be found ([6], [10], [11], [12], [13], etc.). However, due to the diversity of the bioprocesses, there are some problems concerning the development of a unified modeling approach [14]. Also, for control purposes it is necessary to obtain reduced-order models, with some structural properties (linear – nonlinear decoupling, stable – unstable subsystems, the decoupling of uncertain kinetics, etc.). Taking into account these problems, a viable alternative to the classical modeling can be the bond graph method [14].

Bond graph method was introduced by H.M. Paynter, and further developed in several works, such as [15], [16]. The bond graph approach is a powerful tool for modeling, analysis and design of different kind of systems, such as electrical, mechanical, hydraulic, thermal, chemical [17], [18], [19], etc. Among the advantages of bond graph approach we can mention: offers a unified approach for all types of systems; due to causality assignment it gives the possibility of localization of the state

variables and achieving the mathematical model in terms of state space equations in an easier way than using classical methods; provides information regarding the structural properties of the system; offers the possibility of building some complex models by using interconnected submodels.

The structure of the paper is as follows. Section 2 presents some issues regarding the wastewater treatment plants, including the block scheme and functioning principle. Section 3 addresses the bond graph modeling of a complex bioprocess. Actually, a wastewater treatment bioprocess is considered, and the corresponding bond graph model is derived. More precisely, a multi-reactor activated sludge process is studied and bond graph model of the anoxic reactor is obtained. In Section 4 several simulations are performed by using the obtained dynamical model, and the time profiles of the components' concentrations are provided. The simulations are conducted in Matlab programming environment (registered trademark of The MathWorks Inc., USA). Finally, Section 5 collects the conclusions.

2. Wastewater treatment plants

The most common biological wastewater treatment is based on the so-called activated sludge process [5], [6], [20], [21]. However, there are a lot of configurations of this wastewater treatment plant. One of them is the conventional activated sludge system, presented in Fig. 1, where the reduction of oxygen consuming compounds COD (Chemical Oxygen Demand) and, often partly, of the ammonia is the main objective [20]. The involved biological processes are the COD removal and the nitrification. Also, some variations of the conventional activated sludge system are reported [20]. More recent, activated sludge wastewater treatment schemes use the nitrogen removal. Like conventional treatment, nitrogen removal is achieved biologically, and proceeds in two steps (Fig. 2) [20]. The first step is nitrification, which requires an aerobic environment. The second step is reduction of nitrate to molecular nitrogen, referred to as denitrification, requiring abundant COD; in this step the environment is anoxic.
The pilot plant taken into consideration in this work for modeling purposes was used by Lindberg in [21], and it consists of five cascaded tanks: first one anoxic, the next three aerated and the last one is not aerated, all connected to a settler tank. The structure of the pilot plant is presented in Fig. 3 [21].

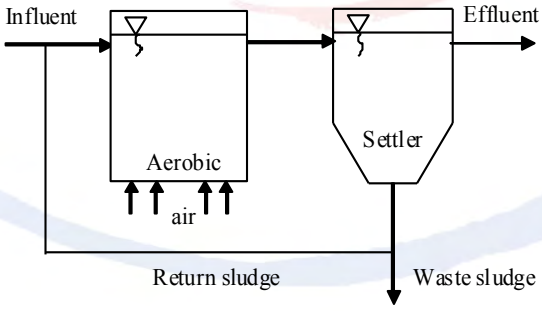

Fig. 1. The scheme of conventional activated sludge plant

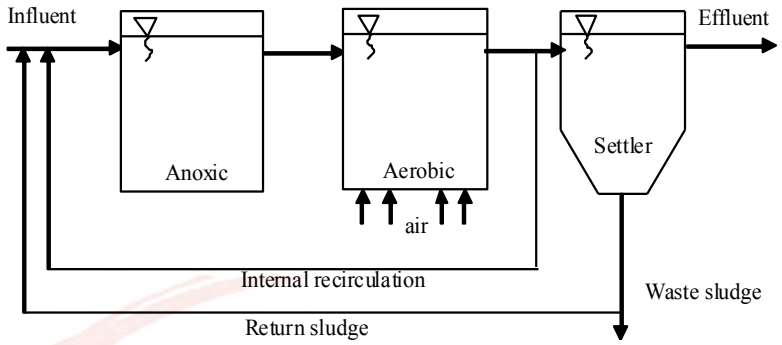

Fig. 2. The scheme of pre-denitrification plant

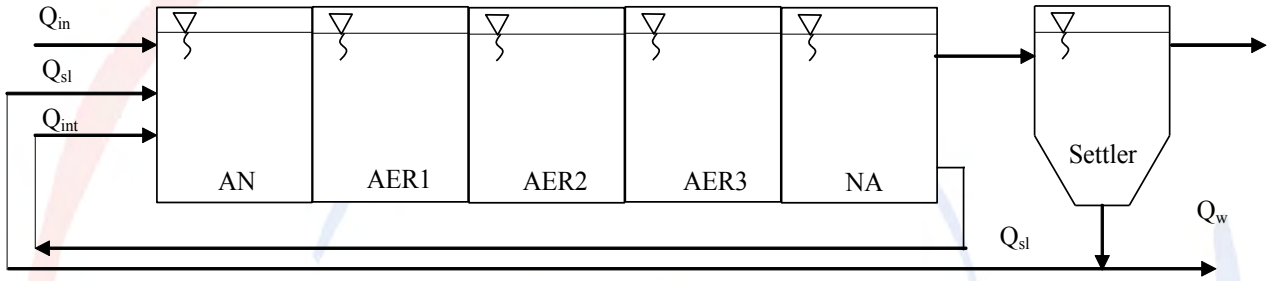

Fig. 3. The interconnected structure of the pilot plant

In Fig. 3, Q_{in} is feed-in flow, Q_{int} - the internal recirculation flow, Q_{sl} - sludge recirculation flow, and Q_w - the sludge outflow from the settler tank. In the first (anoxic - AN) and the last (non aerated - NA) tanks there is no air injection. In the last tank, the oxygen is present coming from previous three aerated tanks (AER1, AER2, AER3). Therefore, the last non aerated tank is still aerobic.

The reaction scheme of the activated sludge process proposed by Henze et al. [22] involves 8 reactions with 10 reaction components [10], [22]:

- Aerobic growth of heterotrophs: $S_S + S_O + S_{NH} \rightarrow X_{BH}$
- Anoxic growth of heterotrophs: $S_S + S_{NO} + S_{NH} \rightarrow X_{BH}$
- Aerobic growth of autotrophs: $S_O + S_{NH} \rightarrow X_{BA} + S_{NO}$
- Decay of heterotrophs: $X_{BH} \rightarrow X_P + X_S + X_{ND}$
- Decay of autotrophs: $X_{BA} \rightarrow X_P + X_S + X_{ND}$
- Ammonification of soluble organic nitrogen: $S_{ND} \rightarrow S_{NH}$
- Hydrolysis of entrapped organics: $X_S \rightarrow S_S$
- Hydrolysis of entrapped organic nitrogen: $X_{ND} \rightarrow S_{ND}$

where S_S is the soluble substrate, S_O - the dissolved oxygen, S_{NH} - the soluble ammonium nitrogen, S_{NO} - the soluble nitrate nitrogen, S_{ND} - soluble biodegradable organic nitrogen, X_{BH} - the heterotrophic biomass, X_{BA} - the autotrophic biomass, X_{ND} - the particulate biodegradable organic nitrogen, X_S - the slowly biodegradable substrate, and X_P - the particulate products [10], [21].

Due to the large number of the components associated to the biochemical process, and also because of the nonlinearity of the transformations within the process, for control purposes it is preferred a reduced order model developed using some simplifying assumptions [6]:

- the dissolved oxygen concentration in not taken into consideration;
- the two fractions of organic matter S_S, and X_S are replaced by a single variable X_{COD} considered to be measurable on-line;
- also, the particulate products X_P are removed in the reduced model;
- only two of the four nitrogen fractions are considered in the reduced model, S_{NH} and S_{NO} (the other two fractions S_{ND} and X_{ND} describe the formation of S_{NH}, which is considered not to be so important for control purposes).

Taking into consideration these assumptions, the reduced model of the activated sludge bioprocess consists of 5 components, introducing a complete separation between the anoxic and the aerobic zones. One of the most difficult modeling procedures concerns the anoxic reactor. The anoxic tank is described by three reactions representing growth of heterotrophs, decay of heterotrophs and decay of autotrophs. The reaction scheme is as follows:

$$\begin{cases} S_{NO} + S_{NH} + X_{COD} \xrightarrow{\varphi_1} X_{BH} \\ X_{BH} \xrightarrow{\varphi_2} S_{NH} + X_{COD} \\ X_{BA} \xrightarrow{\varphi_3} S_{NH} + X_{COD} \end{cases} \quad (1)$$

The reaction scheme (1) will be used in order to achieve the bond graph and the corresponding dynamical model. In the reaction scheme (1), $\varphi_1, \varphi_2, \varphi_3$ are the reaction rates.

3. Modeling of wastewater treatment bioprocess

The classical modeling of a wastewater treatment bioprocess follows the general modeling guidelines valid for a large class of bioprocesses. This approach is widely described in well known monographs such as [7], [10]. In this paper we propose a different technique, based on the bond graph methodology [15], [16], [23]. The result will be a bond graph model, from which a dynamical mathematical model (a set of nonlinear differential equations) will be obtained. This state-space model is equivalent with the model obtained via the classical approach. However, the bond graph model allows us to develop easily some estimation and control strategies, by using the inherent structural properties of a bond graph. Also, the modularity of the bond graph models gives the possibility to reuse the submodels in order to develop large models of interconnected reactors.

Bond graph methodology provides a uniform manner to describe the dynamical behavior of all type of systems. In this paper we use an alternative of this method based on pseudo bonds, which is more suitable for chemical systems due to the physical meaning of the effort e and flow f variables involved. Two other types of variables are very important in describing dynamic systems and these are the generalized momentum p as time integral of effort and the generalized displacement q as time integral of flow [15], [16]. One of the advantages of this methodology is that models of various systems belonging to different engineering domains are represented using a small set of elements: inertial elements (I), capacitive elements (C), resistive elements (R), effort sources (Se) and flow sources (Sf), transformer elements (TF) and gyrator elements (GY), effort junctions (J0) and flow junctions (J1). In biochemical domain, the effort and flow variables have the signification of concentration and mass flow, respectively.

From the reaction scheme (1) and taking into account the mass transfer through the anoxic bioreactor, using the modeling procedure, the pseudo bond graph model of the bioprocess is achieved and is depicted in Fig. 4, where the directions of half arrows correspond to the run of the reactions. The mass balances of the components involved in the anoxic bioreactor (AN) are represented by three five-junctions: $0_{1,2,3,4}$ (mass balance for S_{NO}), $0_{6,7,8,9,26,33}$ (mass balance for S_{NH}), $0_{11,12,13,14,24,35}$ (mass balance for X_{COD}), $0_{17,18,19,20,21}$ (mass balance for X_{BH}), and $0_{27,28,29,30}$ (mass balance for X_{BA}).

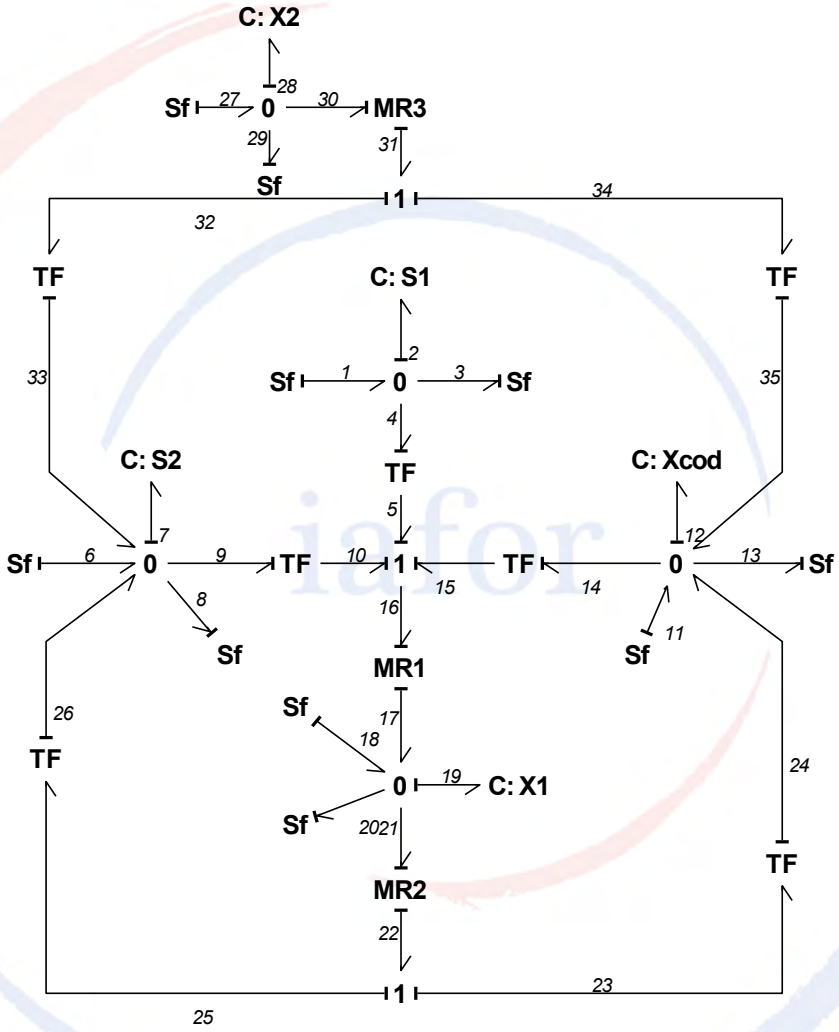

Fig. 4. The pseudo bond graph model of the anoxic bioreactor

In the pseudo bond graph model from Fig. 4, the soluble nitrate nitrogen concentration S_{NO} was denoted by S1, the soluble ammonium nitrogen concentration S_{NH} by S2, the heterotrophic biomass concentration X_{BH} - X1, and the concentration of autotrophic biomass X_{BA} - X2. The same notations were used on the time profiles presented in Section 4.

The constitutive relations of these junctions are characterized by the equality to zero of the sum of flow variables; therefore, the next relations are obtained:

$$f_1 - f_2 - f_3 - f_4 = 0,\ f_6 - f_7 - f_8 - f_9 + f_{26} + f_{33} = 0,\ f_{11} - f_{12} - f_{13} - f_{14} + f_{24} + f_{35} = 0,$$
$$f_{17} + f_{18} - f_{19} - f_{20} - f_{21} = 0,\ f_{27} - f_{28} - f_{29} - f_{30} = 0.$$

Thus, the accumulations of components S_{NO}, S_{NH}, X_{COD}, X_{BH}, and X_{BA} inside the anoxic bioreactor are represented by bonds 2, 7, 12, 19, 28 are modeled using capacitive elements C. The constitutive equations of these elements are as follows:

$$S_{NO}: e_2 = \frac{1}{C_2} q_2 = \frac{1}{C_2} \int_t (f_1 - f_3 - f_4) dt, \quad (2)$$

$$S_{NH}: e_7 = \frac{1}{C_7} q_7 = \frac{1}{C_7} \int_t (f_6 - f_8 - f_9 + f_{26} + f_{33}) dt, \quad (3)$$

$$X_{COD}: e_{12} = \frac{1}{C_{12}} q_{12} = \frac{1}{C_{12}} \int_t (f_{11} - f_{13} - f_{14} + f_{24} + f_{35}) dt, \quad (4)$$

$$X_{BH}: e_{19} = \frac{1}{C_{19}} q_{19} = \frac{1}{C_{19}} \int_t (f_{17} + f_{18} - f_{20} - f_{21}) dt, \quad (5)$$

$$X_{BA}: e_{28} = \frac{1}{C_{28}} q_{28} = \frac{1}{C_{28}} \int_t (f_{27} - f_{29} - f_{30}) dt, \quad (6)$$

where e_2, e_7, e_{12}, e_{19} and e_{28} are the concentrations of components S_{NO}, S_{NH}, X_{COD}, X_{BH}, and X_{BA} (g/m^3). The parameters corresponding to capacitive elements are equal to the anoxic bioreactor volume: $C_2 = C_7 = C_{12} = C_{19} = C_{28} = V_1$, with V_1 (m^3) - the volume of the anoxic reactor.

Mass flows of the components entering the bioreactor are modeled using source flow elements Sf_1, Sf_6, Sf_{11}, Sf_{18}, and Sf_{27}. The output flows of the components are also modeled using Sf elements represented by bonds 3, 8, 13, 20, 29. The constitutive equations of these elements are: $f_3 = Sf_3 e_3$, $f_8 = Sf_8 e_8$, $f_{13} = Sf_{13} e_{13}$, $f_{20} = Sf_{20} e_{20}$, $f_{29} = Sf_{29} e_{29}$, where Sf_3, Sf_8, Sf_{13}, Sf_{20}, Sf_{29} are the parameters of Sf-elements and they are equal to the output flow of the anoxic bioreactor $Q \cdot Z$ (m^3/h), $Q = Q_{in} + Q_{\text{int}} + Q_{sl}$, and Z is the concentration of the corresponding component. The transformer elements TF were introduced to model the yield coefficients $k_i, i = \overline{1,7}$, and for the modeling of the reaction kinetics we used three modulated two-port R-elements: MR1, MR2, and MR3. From the constitutive relations of 1-junction elements $1_{5,10,15,16}$, $1_{22,23,25}$, and $1_{31,32,34}$ we obtain: $f_5 = f_{10} = f_{15} = f_{16}$, $f_{22} = f_{23} = f_{25}$, $f_{31} = f_{32} = f_{34}$, where the constitutive relations of MR elements imply that $f_{16} = \varphi_1 V_1$, $f_{22} = \varphi_2 V_1$, $f_{31} = \varphi_3 V_1$, with φ_1, φ_2, φ_3 being the reaction rates; $\varphi_1 = \mu_H e_{19}$, $\varphi_2 = b_H e_{19}$, $\varphi_3 = b_A e_{28}$, μ_H - the specific growth rate of heterotrophs, b_H, b_A – the decay rate of heterotrophs and autotrophs.

The signification of bond graph elements is as follows: e_2 is the soluble nitrate nitrogen concentration S_{NO} (g/m^3), e_7 - the soluble ammonium nitrogen concentration S_{NH} (g/m^3), e_{12} - the organic matter concentration X_{COD} (g/m^3), e_{19} is the heterotrophic biomass concentration X_{BH} (g/m^3), e_{28} is the concentration of autotrophic biomass, X_{BA} (g/m^3); the input flows f_1, f_6, f_{11}, f_{18}, and f_{27} are equal to the corresponding $Q_{in}Z_{in} + Q_{int}Z_{int} + Q_{sl}Z_{sl}$ (g/h), where Z represents the concentration of each component. Using these notations, from (2)-(6) we will obtain the mass balance equations of the bioprocess from the anoxic tank:

$$\dot{S}_{NO} = \frac{Q_{in}S_{NOin} + Q_{\text{int}}S_{NO\text{int}} + Q_{sl}S_{NOsl}}{V_1} - \frac{Q_{in}+Q_{\text{int}}+Q_{sl}}{V_1}S_{NO} - k_1 r_H X_{COD} X_{BH} \quad (7)$$

$$\dot{S}_{NH} = \frac{Q_{in}S_{NHin} + Q_{\text{int}}S_{NH\text{int}} + Q_{sl}S_{NHsl}}{V_1} - \frac{Q_{in}+Q_{\text{int}}+Q_{sl}}{V_1}S_{NH} - k_2 r_H X_{COD} X_{BH} + \quad (8)$$
$$+ k_3 b_H X_{BH} + k_4 b_A X_{BA}$$

$$\dot{X}_{COD} = \frac{Q_{in}X_{CODin} + Q_{\text{int}}X_{COD\text{int}} + Q_{sl}X_{CODsl}}{V_1} - \frac{Q_{in}+Q_{\text{int}}+Q_{sl}}{V_1}X_{COD} - k_5 r_H X_{COD} X_{BH} + \quad (9)$$
$$+ b_H X_{BH} + b_A X_{BA}$$

$$\dot{X}_{BH} = \frac{Q_{in}X_{BHin} + Q_{\text{int}}X_{BH\text{int}} + Q_{sl}X_{BHsl}}{V_1} - \frac{Q_{in}+Q_{\text{int}}+Q_{sl}}{V_1}X_{BH} + r_H X_{COD} X_{BH} - \quad (10)$$
$$- b_H X_{BH}$$

$$\dot{X}_{BA} = \frac{Q_{in}X_{BAin} + Q_{\text{int}}X_{BA\text{int}} + Q_{sl}X_{BAsl}}{V_1} - \frac{Q_{in}+Q_{\text{int}}+Q_{sl}}{V_1}X_{BA} - b_A X_{BA} \quad (11)$$

where the production coefficients are: $k_1 = \frac{1-Y_H}{2{,}86Y_H}$, $k_2 = k_3 = k_4 = i_{XB}$, $k_5 = \frac{1}{Y_H}$, with Y_H - the heterotrophic yield and i_{XB} - mass N/mass COD in biomass.

The specific growth rate of heterotrophs is modeled using a double Monod law:

$$r_H = \mu_H \left(\frac{S_{NO}}{K_{NO} + S_{NO}} \right) \left(\frac{1}{K_S + X_{COD}} \right)$$

where K_{NO} is the nitrate half-saturation coefficient for denitrifying heterotrophs, and K_S is the half-saturation coefficient for heterotrophs.

Thus, the model of the anoxic reactor is represented by relations (7)-(11). However, to obtain the full model of interconnected reactors, it is necessary to design the bond graph models of the aerobic reactors and of the non aerated reactor. Then the full dynamical model can be obtained by combining the corresponding submodels.

4. Simulation results

The behavior of the obtained bioprocess model was tested using numerical simulations, by using the Matlab programming environment (registered trademark of the MathWorks Inc., USA). The wastewater treatment bioprocess has been simulated for process parameters presented in Table 1 [6]. The values of influent concentrations are given in Table 2, and the initial conditions of state variables, in Table 3 [6].

Table 1. Parameters for Activated Sludge Model No. 1

Symbol	Value
Y_H	0,67
i_{XB}	0,086 g N (g COD)$^{-1}$
μ_A	0,8 (day)$^{-1}$
μ_H	6 (day)$^{-1}$
K_S	20 g COD m^{-3}
K_{OH}	0,2 g O_2 m^{-3}
K_{NO}	0,5 g NO_3^- N m^{-3}
K_{NH}	1,0 g NH_3^- N m^{-3}
b_A	0,2 (day)$^{-1}$
b_H	0,62 (day)$^{-1}$
V_1	0,46 (m^3)

Table 2. Values of influent concentrations

State	S_{NOin}	S_{NHin}	X_{CODin}	X_{BHin}	X_{BAin}
[g/m^3]	1	25	160	25	0

Table 3. The initial conditions of state variables

State	S_{NO}	S_{NH}	X_{COD}	X_{BH}	X_{BA}
[g/m^3]	1	20	106	250	60

The time evolution of state variables (i.e. the concentrations) was obtained by numerical integration of the dynamical model equations (2)-(6). The integration method was a variable order multistep solver based on numerical differentiation formulas (in Matlab). From the time profiles presented in Figs. 5-9, it can be seen the typical evolution inside activated sludge wastewater treatment plants.

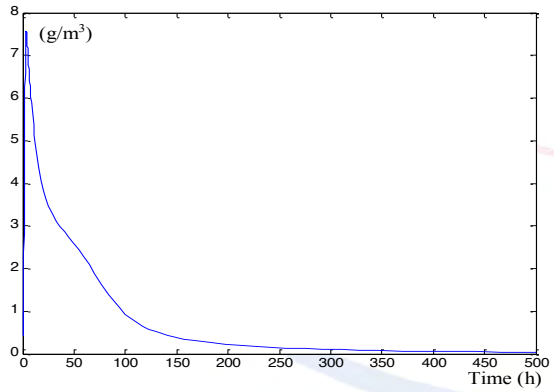

Fig. 5. Time evolution of soluble nitrate nitrogen concentration

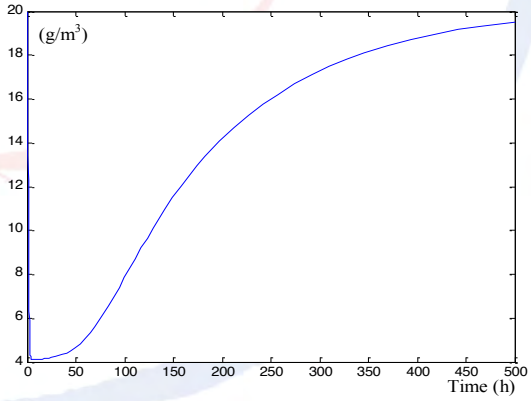

Fig. 6. Time evolution of soluble ammonium nitrogen concentration

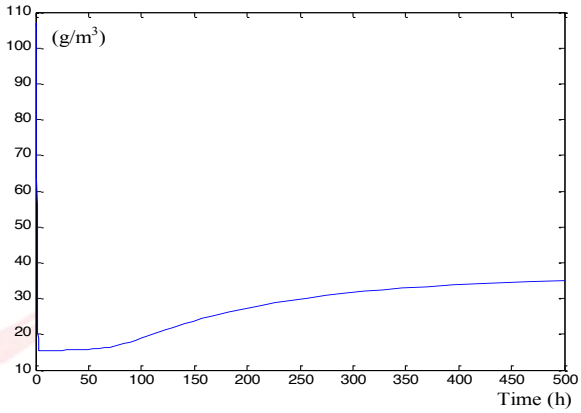

Fig. 7. Time profile of organic matter concentration

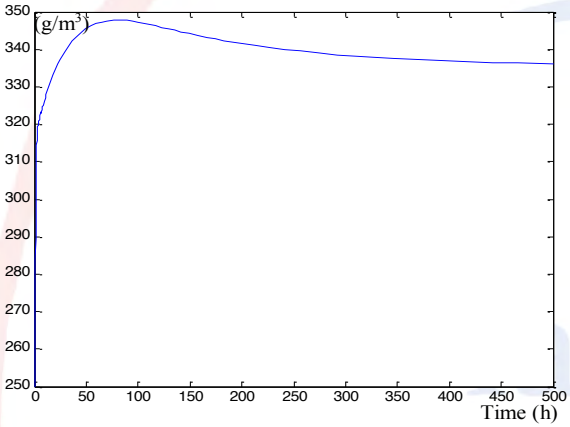

Fig. 8. Time evolution of heterotrophic biomass concentration

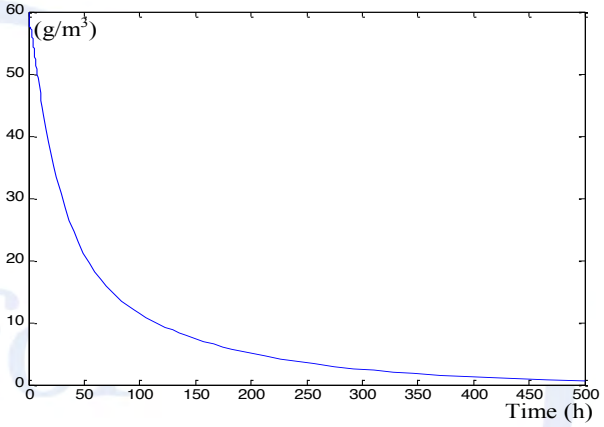

Fig. 9. Time evolution of autotrophic biomass concentration

It should be mentioned that the presented evolution is obtained in open loop, i.e. we don't implemented any control strategy. In order to obtain good performance of the wastewater treatment process, it is necessary to "close the loop", by designing and implementing a control strategy. The design of such strategy consists in the development of some estimation and control algorithms by using the obtained reduced model, but this design is beyond the aim of this paper.

5. Conclusion

Biotechnological processes used for wastewater and organic waste treatment are very important in the field of environmental protection. For such a reason, in this paper the modeling and simulation of the activated sludge wastewater treatment bioprocess was considered, in order to understand the behavior of this process. This allows the improvement of the efficiency of the plants, and the implementation of various estimators and control strategies. First, the graphical model of the anoxic reactor of the plant were obtained, followed by the achievement of the correspondingly dynamical models. Several simulations were also provided.

Acknowledgement

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Thermal Pre-Treatment Solutions For Low Quality Fuels To Energy Conversion

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Abstract:

The paper presents the results on waste to energy conversion solutions using thermal-chemical processes for raw product combustible properties improvement. The research focused on biodegradable waste conversion using pyrolysis and gasification processes with respect to global energy efficiency using pre-treatment stage for by-products formation. Food industry residues from meat processing lines were used. Laboratory batch reactor and semi-industrial pilot plant specially designed were used for the experimental campaigns. The paper presents the complete conversion process characterization and by-products properties: composition, low heating value etc. Based on experimental results different treatment chains with energy recovery solutions are proposed.

1. Introduction

Large quantities of waste with specific, different characteristics are generated by food processing industry. One of the most important industries in the food chain is the meat processing with big amounts of waste generated every year. Due to waste particularities the poultry processing line generates problematic residues with respect to their bacteriologic potential if disposed to the landfill [1]. Over 4 million tons of poultry waste: feathers, bones, claws, blood, head and skins are generated by the increasing growth of poultry processing industry [2]. Because of the relatively cheap price of poultry meat in comparison with other meat industries and world population growth every year, the poultry waste from the processing line is a predictable increasing residue. Another problem raised by this waste is the negative environmental impact based on an inadequate waste management solution. Currently, the most developed poultry slaughterhouses are using a process of sterilization of waste to produce an inert product suitable for landfilling at high costs [3]. The problems are raised by the small slaughterhouses that do not have integrated waste neutralization and disposal technologies. Nevertheless the currently used solutions for residues disposal are not energy efficient if common incineration is used previous to landfill [4]. These solutions increase the lack of interest in a good waste management approach with negative effect on environment by air, soil and water pollution damaging also the human healthcare.The predictable quantities and theconstant waste composition generated by poultry processing industry could represent potentially valuable resource for the energy industry. Poultry feathers are the most keratinous product that exists (91%), small amounts of lipids 1% and 8 % water, thereby the use of a biological process to convert such waste in energy via digestion is not suitable because is leading to some by-products, during anaerobic degradation, which are toxic and inhibitory to anaerobic microorganisms [5]. The strict regulations and the decentralized production make this waste too expensive and unattractive fuel resource for the energy sector but still could be profitable by savingdisposal costs thorough power generation. If waste to energy conversion is applied the industrial electricity and heat consumption of the slaughterhouses can be covered. The valorization method investigated within this study is the waste to energy conversion using thermal-chemical processes.

2. Experimental set-up

Product characterization

For the experimental campaign were used residues (chicken feathers) from a poultry slaughterhouse. The raw feathers humidity content is up to 70%. The product is presented as a mixture of feathers blood, offal and other slaughterhouse residues. For product characterization, the chicken feathers were subjected to a drying sequence in an oven for 24 h at temperature 105 ºC. The EuroEA 3000 series elemental analyzer was used for elemental composition determination.The product elemental composition (dry basis) is: C – 60.6%, H – 8.5%, N – 8.7%, S – 4.8%, O – 13.3%, Cl – 2.6%, Ash – 1.5% [6]. The high values of combustible elements show that the calorific value of waste will be high. The low heating value of the sample was determined using a calorimeter IKA C 200 system – 26139 kJ/kg (dried sample). The high content of N_2 can be explained by the poultry food alimentation rich in nitrogen based products. The content of sulfur is due to blood, offal and other residues presence in waste mixture.

Installations

For the pyrolysis process run a modified batch tubular reactor was used [6]. The reactor is made by a refractory stainless steel tube, exterior electrically heated with inner diameter of 60 mm. The isothermal active heating zonelength is of 750 mm. The refractory stainless steel tube has two outlet tubes made for gas and liquid discharges resulted from treatments applied to solid masses. Two inlets are also present. The maximum operating temperature within active zone temperature of the reactor is 1300°C. The installation is equipped with a control pad that allows temperature programming, working time (residence time at process temperature) and heating rate. Samples to be subjected to treatment processes are introduced into the furnace in a tubular parallelepiped crucible of refractory steel.

The second experimental installation is a rotary kiln reactor also externally heated, with a maximum load of 30 kg/h, designed and operated within Renewable Energy Sources Laboratory from Polytechnic University of Bucharest (Figure 1). The reactor is equipped with air/oxygen/steam injection and thermocouples for internal temperature measurement/control. At the evacuation end a gas sampler is connected to a GC-MS system. The installation has a batter system for different angles for sample advancement and ash elimination.

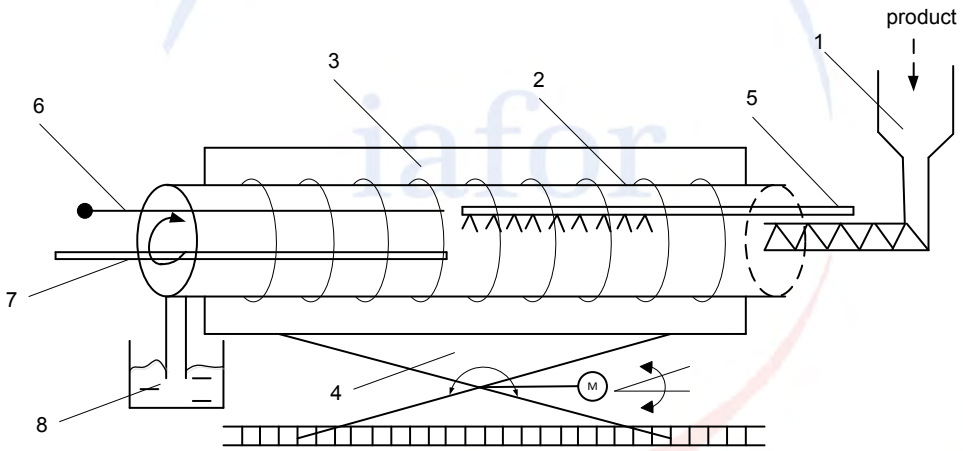

Fig. 1. Sample screw feeder; 2. Rotary kiln reactor; 3.Heated envelope; 4.Batter system; 5. Steam injection; 6. Thermocouple; 7.Gas sampling; 8.Ash collector.

The installation enables the continuous treatment of solid products under vapor / air – gasification. The gasification experiments were carried out at 650°C - 800°C. The product is continuously feed-in at 1kg/hour.

3. Results and discussion

Pyrolysis process

The pyrolysis process was conducted at temperatures in range 450 °C – 800 °C for 45 minutes at heating rate of 30 °C/min. To ensure an inert atmosphere in the reactor during the pyrolysis process, nitrogen was injected and the flow was measured using a flow controller.

The pyrolysis by-products distribution (char, tar and gas) is showed in Figure 2. As can be seen the component fraction variation depends on the pyrolysis temperature, heating rate and residence time.

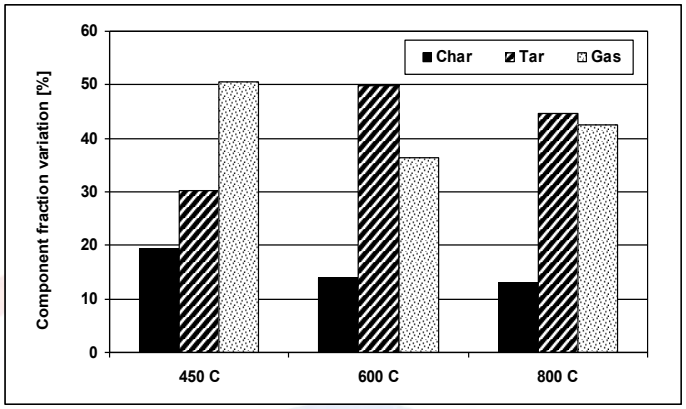

Fig. 2 Pyrolysis byproducts distribution depending on process temperature

At high pyrolysis temperature the links C-C in the solid matrix are breaking with direct effect on char production that decreases with temperature. A high temperature favors the production of non-condensable gases compared with liquids and solids. The tar fraction is maximum at 600°C decreasing at 800°C when secondary pyrolysis and gaseous cracking reactions occurs. The maximum gas fraction is obtained at 450°C as well as char. If combined pyro-gasification is used the interest for low temperature pyrolysis is sustained by maximum char fraction and tar to be gasified.

Gasification process

Two types of waste to energy conversion chains were used: pyro-vapor-gasification and direct air gasification (Figure 3.).

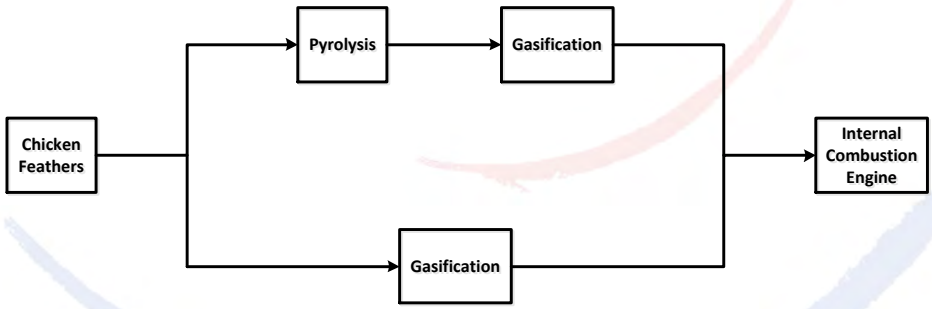

Fig. 3 Waste to energy conversion chains

Due to industrial technology maturity the air gasification does not rise challenges in terms of operation parameters, specific flows and process modeling. Consequently, the experimental campaign was conducted for pyro-vapor-gasification. Due to gasification process instability the continuous operation in the rotary kiln reactor was used. The gasification process was conducted in two steps: pyrolysis and char gasification. For both stages external heating was used. The vapor gasification agent was supplied by a steam generator. The process gas composition was continuously monitored with Shimadzu QP 2010Plus GC-MS at a sampling sequence of 1 at every 20 min. For the air gasification conditions the results were delivered by computation. Therefore, based on product proximate and ultimate analysis and industrial process operation parameters the syngas specific flow rate and composition was delivered.

For the vapor - gasification process the feed-in product consists in char from pyrolysis stage (homogenous char coal like) with a low heating value about 28000 kJ/kg. The experimental measurements revealed a LHV of about 11000 – 12000 kJ/kg for the delivered syngas. The optimum syngas / char ratio obtained for this LHV was 4.1 kg_{syngas} / 1 kg_{char}. Because the vapor-gasification is conducted on waste pyrolysis char the raw product humidity does not influence the gasification process or the syngas flow and quality. Low temperature pyrolysis conducted at 350ºC – 450ºC and high temperature steam gasification at 850ºC – 950ºC were used.
For the direct air gasification process the product used (raw waste) had humidity between 0% and 30%. The product LHV varies from 26139 kJ/kg to 18297 kJ/kg. The syngas LHV decreases from 5500 kJ/kg to 1100 kJ/kg (Figure 4).

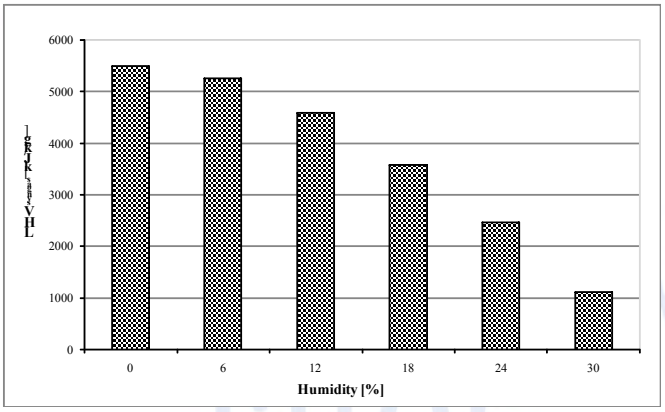

Fig. 4. The influence of waste humidity on syngas quality under air gasification conditions.

The computed syngas / waste ratio varies from 3.8 to 4.74 kg_{syngas} / kg_{waste} (Figure 5). The waste water content slightly influence the syngas production. Nevertheless the hydrogen and oxygen contained in the completely dried waste is sufficient for the water vapors formation required by the air gasification process.

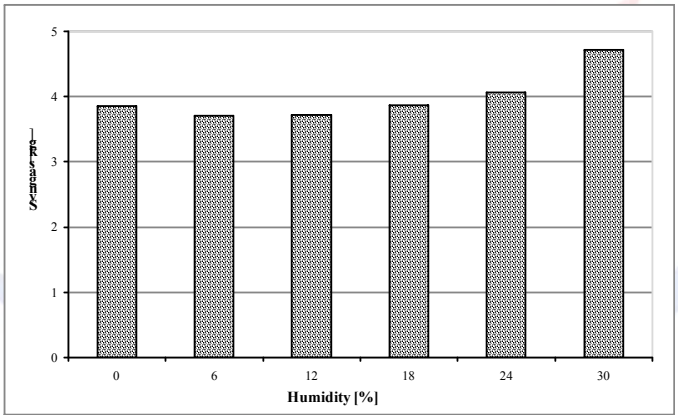

Fig. 5. The influence of waste humidity on syngas quality under air gasification conditions.

We notice that the specific syngas flow increases with about 1 kg_{syngas} / kg_{waste} when the waste humidity increases from 0% to 30%. Nevertheless the syngas LHV decreases to 1100 kJ/kg mainly due to severe hydrogen content reduction (Figure 6).

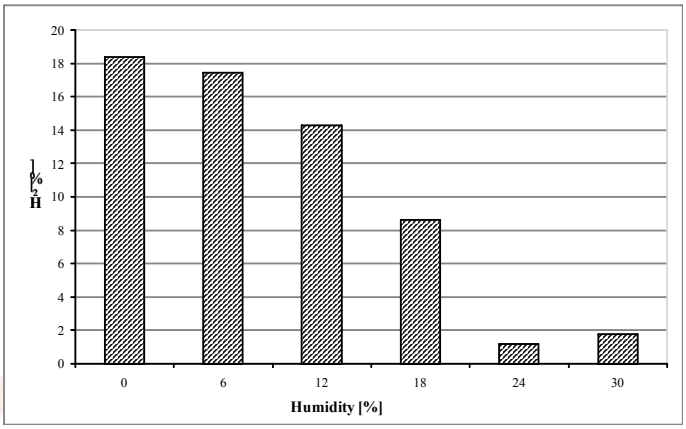

Fig. 6. The influence of waste humidity on syngas hydrogen content under air gasification conditions.

The hydrogen content decreases from 18.2% when dried waste is used to 1.6% if product humidity is 24%. Within 0% and 12% humidity the hydrogen content is relatively stable. After 18% humidity its fraction decreases rapidly. The slightly hydrogen increase at 30% occurs due massive presence of water vapors that enable the methane formation reaction. Nevertheless the temperature level, relatively low (590°C – 750°C) is not sufficient to initiate the vapor gasification reactions.
This syngas obtained from waste with humidity above 24% cannot be used in internal combustion engines, but only for heat production.

Power generation

To compare the energy conversion chains a series of assessments were made with respect to technology configurations processes global energy efficiency and equipments efficiencies. For the air gasification processing down-draft gasifiers can be used. The only restrictions are introduced by: product humidity that must be reduced from 70% to 25% and product physical structure that require specific shredding and feed-in devices. For the pyro-vapor-gasification processing combined technologies can be used. For the pyrolysis stage: rotary kiln, externally heated. Nitrogen injection at start-up (gas exhaust from thermal engine can be used). For the gasification stage: rotary kiln externally heated / down draft reactor with steam injection. The thermodynamic cycle is common to both technologies and consists in internal combustion engine, Diesel-Gas type. The energy efficiency considered in our computation was chosen according to each equipment characteristics and power range. To minimize the energy loss with pyrolysis by-products sensitive heat the pyrolysis stage is directly connected to gasification one.
The experimental and computed results show that for the complete dried product the maximum electric energy is provided by direct air gasification (Figure 7).

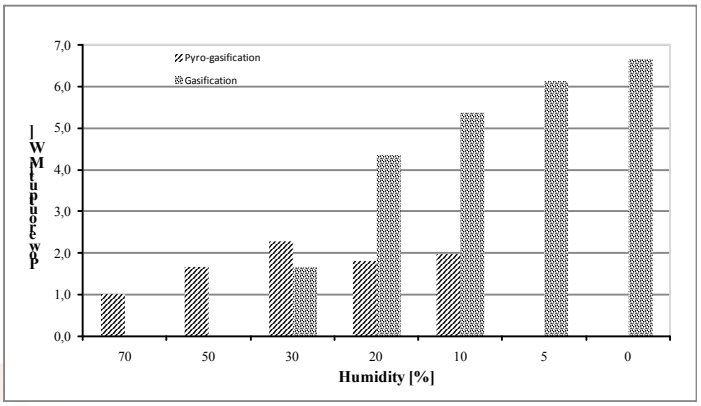

Fig. 7. Net electric output from poultry waste feathers using gasification based processes.

This solution is also the simplest one in terms of technology architecture and materials due to moderate temperature. The investment, operation and maintenance costs are also inferior to vapor-gasification. As the waste humidity increases the net power output decreases from 6.7 MW till it reaches its minimum of 1.6 MW at 30% humidity. The values were obtained for a feed-in flow of 1 kg/s of waste equivalent to 86.4 tons/day. This quantity is specific to medium – high capacity slaughterhouses. At 30% humidity the air gasification cannot be used for power generation because the delivered syngas reaches its minimum LHV of 1100 kJ/kg. The syngas energy could produce 1.7MW but the gas composition is unfitted for internal combustion engine. Because the raw waste has the humidity of about 70% the drying is required to decrease the water content. The high amount of water restricts the thermal drying as solution. The only viable option is the mechanical drying. Due to physical structure of the product, previous attempts did not succeed in decreasing the water content below 50% [7]. Consequently the air gasification required additional thermal drying that will significantly decrease the net energy output from the system.
The alternative solution is provided by pyro-vapor-gasification that even at 70% humidity delivers about 1 MW for the feed-in flow considered. If mechanical drying is used, at 50% humidity the net electric energy that can be obtained is about 1.7 MW. For this case the proposed process configuration could represent the viable solution for the humidity range between 70% and 50% (the real case situation). The research revealed that the maximum power out-put could be reached at 30% humidity of the product. To optimize the waste to energy conversion chain the water vapor liberated in pyrolysis stage can be used in gasification process as internal heat recovery and global efficiency increase.

4. Conclusions

The paper presents the results of the study for optimal waste to energy conversion chain applied to chicken waste feathers, a product with high water content unfitted for energy recovery processing. The combined experimental and computational results revealed that two gasification based processes can be used for waste energy potential recovery: direct air gasification and pyro-vapor-gasification. For product humidity below 24% the direct air gasification provides maximum power output. The only restriction is introduced by the drying sequence that should be mechanical for minimum energy consumption. Above 24% humidity the syngas cannot be used in internal combustion engines due to very low calorific value (1100 kJ/kg). The maximum syngas LHV obtained by air gasification does not exceed 5500 kJ/kg. Within 0% and 24% humidity the net electric energy varies between 6.7 MW

and 1.9 MW for a feed-in of 1 kg/s of waste equivalent to 86.4 tons/day, specific to medium – high capacity slaughterhouses.
For products that exceed 30% of water content the pyro-gasification process represents the best solution for energy conversion. The process manages to deliver a net power of 2.3 MW that decreases to 1 MW for 70% humidity. Different technological solutions optimized by integrating distinct processing stages and internal energy recovery can be used: the water vapor liberated in pyrolysis stage used as gasifying agent; the engine exhaust gases used for pyrolysis stage energy supply; aiming for conversion chain global energy efficiency improvement.

Acknowledgement

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Simulation and Optimization of Designed Parameters for a Desiccant Column in Radiant Cooling System

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Abstract:

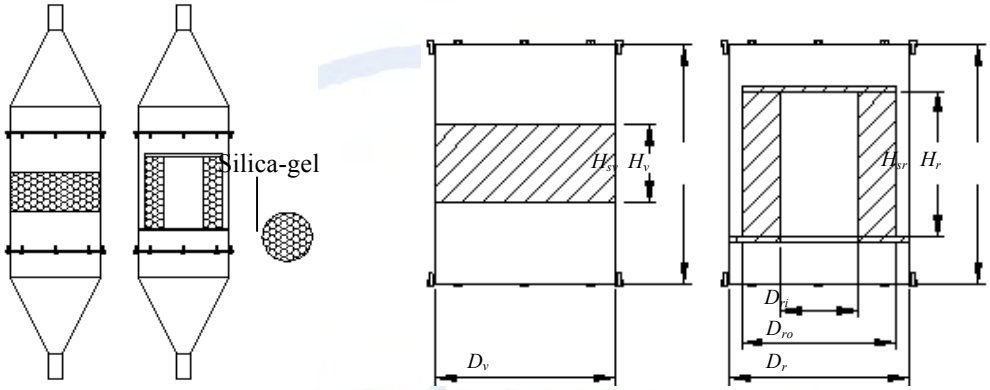
This paper concentrates on the numerical simulations of desiccant column with various dimension of designed parameters for optimization in order to minimize the value of pressure drop (ΔP) and maximize the value of adsorption rate (ΔW). The comparing beds under investigation were vertical flow and radial flow with approximately 3 mm diameter of silica-gel as the working desiccant in the column. The ranges of the geometrical designed parameters were 0.2, 0.3, 0.4 m for diameter of vertical flow bed (D_v); 0.75, 1.00, 1.25 for ratio of outer diameter of radial flow bed (D_{ro}) to diameter of vertical flow bed and 0.375, 0.500, 0.625 for ratio of inner diameter of radial flow bed (D_{ri}) to outer diameter of radial flow bed. Twenty-seven simulation test units of radial flow bed with different values of diameter ratio were used. For all units, amount of desiccant in the bed being 10 kg of silica-gel, column volume of 0.045 m^3 and ventilation air of 26 kg/h were used in the simulations. Results implied that the practical optimum zone of the inner diameter and outer diameter of the radial flow bed are 0.15 m and 0.30 m, respectively. The optimum condition values are 23.34 Pa and 0.4634 kg_w/h.

Introduction

A principal purpose of Heating Ventilation and Air Conditioning (HVAC) is to provide thermal comfort conditions for human which is to provide thermal comfort conditions for human which is the condition of mind that expresses satisfaction with the thermal environment. In general, comfort occurs when body temperatures are held within narrow ranges, skin moisture is low, and the physiological effort of regulation is minimized. As reference by ANSI/ASHRAE Standard 55-1992 [1], the acceptable ranges of operative temperature and relative humidity are 20-26^{o}C and 30-60%, respectively. In the tropical region, such as Thailand climatic zones, it is valid under the conditions of 26^{o}C and 50-60% relative humidity being a comfortable environment condition [2]. Air-conditioning loads can be divided into two components, namely the sensible and the latent loads. An air conditioner must counterbalance the two sorts of load in order to maintain the desired indoor conditions. The radiant cooling systems which are an alternative to convective air-conditioning systems use temperature-controlled indoor surfaces on the walls and ceiling. The temperature is maintained by cooled water passing through the radiant cooling panel which made from copper tube bond with aluminium sheet. The comfort levels can be better than other space-conditioning systems because thermal loads are satisfied directly, air motion in the space corresponds is required only ventilation [3]. However, it can satisfy only sensible heating. In the area of high humidity, the ambient air brings in a lot of surplus moisture. The moisture presents the major problem for the human comfort and the air-conditioning systems, so unitary dehumidifiers should be used. Both mechanical refrigeration systems and desiccant can remove the moisture from the supply air, whereas desiccant dehumidification is advantageous in dealing with latent load and improving indoor air quality because of adsorbing moisture directly and capturing the contamination of the air simultaneously. The desiccants are natural or synthetic substances capable of absorbing or adsorbing water vapour due to the difference of water vapour pressure between the surrounding air and the desiccant surface. Many desiccant materials are available, such as silica-gel, activated alumina, molecular sieve, alumina gel, etc. In other words, silica-gel has a high capacity for water, a low temperature for regeneration, and no sulfur conversion reactions [4]. Desiccant column are also widely used in the process of air dehumidification or drying. There are several desiccant column configurations including solid packed bed, multiple vertical bed, rotating honeycomb, radial bed, fluidized bed, and inclined bed which have been used for dehumidification. Theoretical and experimental study on the transient adsorption characteristics of a solid packed porous bed were studied by Hamed [5]. Kabeel [6] studied on the adsorption-desorption operations of multiple vertical bed for dehumidification applications which were to investigate the effect of the packed bed length on the bed performance. Increasing the bed length will improve the state of the exit air (decreases humidity) but increase the pressure drop and hence increasing the power consumption. Evaluation and optimization of solar desiccant wheel (rotating honeycomb) performance was reported by Ahmed et al. [7]. Adsorption-desorption operations of a hollow cylindrical packed bed were investigated by Awad et al. [8]. The pressure drop in radial bed is too small comparing with that for the vertical bed. Moreover, the increasing in pressure drop was found with increasing in bed diameter ratio (outside/inside). Also, higher values of bed diameter ratio can be used to improve the dehumidification rate for short periods of operation. Hamed et al. [9] studied experimentally the transient adsorption-desorption characteristics of silica gel particles in fluidized bed. In this study, the desiccant column was used in dehumidifying the incoming ventilation air stream by forcing it through a structured packing impregnated with silica-gels for the radiant cooling systems. The three-level factorial design is employed to optimize the designing parameters of desiccant column in order to obtain the low pressure drop and the high adsorption rate by using the commercial finite volume flow solver Fluent on ANSYS version 13.0 software.

Methodology

Desiccant Column Design. In simulation study, spherical particles of silica-gel were used as the working desiccant in the column. The physical properties of silica-gel are 3 mm diameter, porosity of 0.4 (the open volume fraction of the medium) and bulk density of 670 kg/m^3. For comfort condition design [2], requirement of silica-gel in the bed was 10 kg with column volume 0.045 m^3 and ventilation air of the radiant cooling system 26 kg/h. The desiccant beds under investigation were the vertical flow and radial flow, as shown in Fig. 1a. The dimensions of designed parameters are shown in Fig. 1b where H_{sv}, H_v and D_v represent height of silica-gel, height and diameter of the vertical flow bed, respectively, whereas H_{sr}, D_{ri}, D_{ro}, H_r and D_r represent height, inner and outer diameter of silica-gel, height and diameter of the radial flow bed, respectively.



(a) Vertical and radial flow bed (b) Dimensions of desiccant column

Fig. 1 Schematic of desiccant column and designed parameters

The 3^3 Factorial Design. The three-level factorial design is employed to optimize the designing parameters of desiccant column in order to obtain the low pressure drop and the high adsorption rate. The studied of designing parameters are the diameter of the vertical flow bed, and the inner diameter and the outer diameter of the radial flow bed. The desired responses are the pressure drop and the adsorption rate which assumed to be affected by three independent variables as mentioned earlier. In the 3^3 factorial design, the quantitative form of relationship between desired responses and independent input variables can be represented as following.

$$Y = f(D_v, D_{ro}, D_{ri}) \tag{1}$$

Where Y is the desired responses and f is the response function. In this study, the approximation of Y is proposed using the various fitted regression models, i.e. liner with interaction model, quadratic model and squared with interaction model. The model proposed for the response Y can be represented as following [10].

$$Y = \beta_0 + \sum_{i=1}^{k} \beta_i X_i + \sum_{i=1}^{k} \beta_{ii} X_i^2 + \sum_{i<j}^{k} \beta_{ij} X_i X_j + E \tag{2}$$

Where β_0 is constant, β_i, β_{ii}, β_{ij} represent the coefficients of linear, quadratic and cross product terms, respectively and E is the random error. X_i, X_j reveal the coded variables corresponding to the studied designing parameters.

Responses and Factors. The three levels of the geometrical designed parameters were chosen to obtain the low pressure drop and the high adsorption rate. These level settings are presented in Table 1 which denote the low, intermediate, and high levels by -1, 0, and +1, respectively. The

simplest design in the 3^3 factorial design, which has three factors, each at three levels. Therefore, the CFD simulations are 27 treatment combinations.

Table 1 The simulation range and levels of designing parameter

Parameters	Ranges and levels		
	Low (-1)	Intermediate (0)	High (+1)
Diameter of vertical flow bed, D_v (m)	0.2	0.3	0.4
Outer diameter of radial flow bed, D_{ro} (m)	$0.75\times D_v$	$1.00\times D_v$	$1.25\times D_v$
Inner diameter of radial flow bed, D_{ri} (m)	$0.375\times D_{ro}$	$0.500\times D_{ro}$	$0.625\times D_{ro}$

Computational Fluid Dynamics (CFD) Model. The simulations were performed using the commercial finite volume flow solver Fluent on ANSYS version 13.0 software. In this study, the desiccant column dehumidification involves modeling the multiphase flow through porous media. Mixture model in the Euler-Euler approach is a simplified multiphase model that can be used in different ways. It can be used to model multiphase flows where the phases move at different velocities, but assume local equilibrium over short spatial length scales. Moreover, it can be used to model homogeneous multiphase flows with strong coupling and phases moving at the same velocity. The porous media model which using for a wide variety of single phase and multiphase problems, including flow through packed beds, filter papers, perforated plates, flow distributors, and tube banks are modeled by the addition of a momentum source term to the standard fluid flow equations. The source term is composed of two parts namely, a viscous loss term, and an inertial loss term. In the simple homogeneous porous media case, it can be represented as following [11].

$$S_i = -\left(\frac{\mu}{\alpha}v_i + C\frac{1}{2}\rho|v|v_i\right) \quad (3)$$

Where S_i is the source term for the momentum equation ($kg/m^2.s^2$), $|v|$ is the magnitude of the velocity, μ and ρ being dynamic viscosity ($N.s/m^2$) and density of fluid properties (kg/m^3), respectively, α is the permeability and C is the inertial resistance factor. Under the finite volume method [12], although the first-order upwind scheme discretization can yield better convergence, it will lead to less accurate results. Therefore, the quadratic upwind differencing scheme (QUICK scheme) discretization is used in calculating momentum, volume fraction, turbulence kinetic energy and its dissipation rate, and Reynolds stress equations. SIMPLEC arithmetic is used in pressure-velocity coupling in order to accelerate the convergence of continuity equation. PRESTO! scheme is applied in discretizing pressure gradient taking into account non-staggered grid.

Results and Discussion

Comparison between Vertical Flow Bed and Radial Flow bed. Under the conditions with amount of desiccant in the bed being close to 10 kg of silica-gel, column volume of 0.045 m^3 and air ventilation of 26 kg/h, the pressure drop and the adsorption rate comparisons between vertical flow bed and radial flow bed are depicted in Fig. 2. In case of bed diameter between 0.20 to 0.45 m, increasing vertical flow bed diameter decreases the pressure drop within the column and varies the adsorption rate around 0.4615 kg_w/h, and increasing radial flow bed diameter rises the pressure drop and the adsorption rate simultaneously. However, the pressure drop of vertical flow bed is too high comparing with the radial flow bed under the same column diameter, but the adsorption rate of the radial flow bed is usually higher than the other one for the column diameter more than 0.32 m.

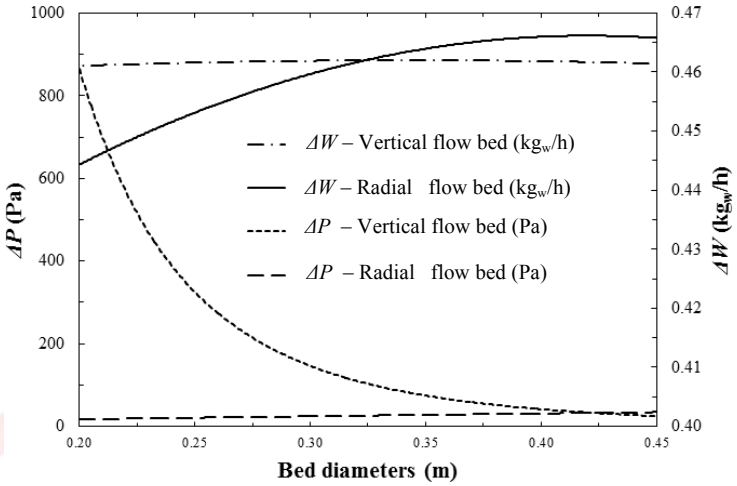
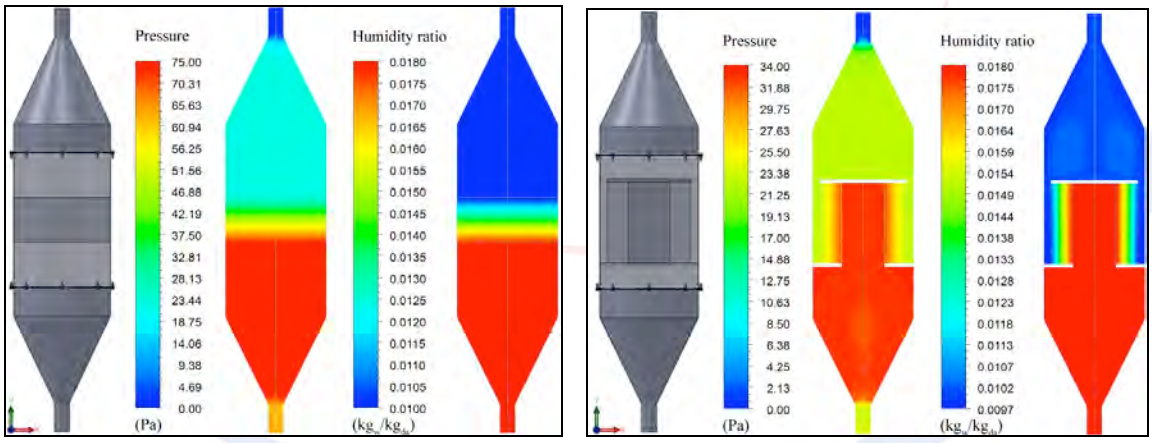


Fig. 2 Pressure drop and adsorption rate for various bed diameters

The static pressure and humidity ratio distributions within the column with mass flow rate of 26 kg/h for bed diameter 0.35 m predicted through simulation are given in Fig. 3. The magnitudes of capacities are represented with collections of colours which the meanings of these colours are explained with the vertical colour bars in the figure. The vertical flow bed had high static pressure (63 Pa) in bottom column or inlet zone (orange zone) and zero Pa (gage) in outlet zone to ambient (blue zone). Moreover, the radial flow bed had less pressure drop than 23.34 Pa. For moisture air with inlet humidity ratio of 0.0180 kg_w/kg (red zone) passed through desiccant media, outlet humidity ratio of the vertical and radial flow bed decreased to 0.0100 kg_w/kg (blue zone). Furthermore, the incoming process of air-stream was forced from bottom column through desiccant media inside dehumidifier. The maximum magnitude of velocity was occurred in the centre and middle layer of the column. The reverse swirl was found the near inlet and outlet region of the radial flow bed.

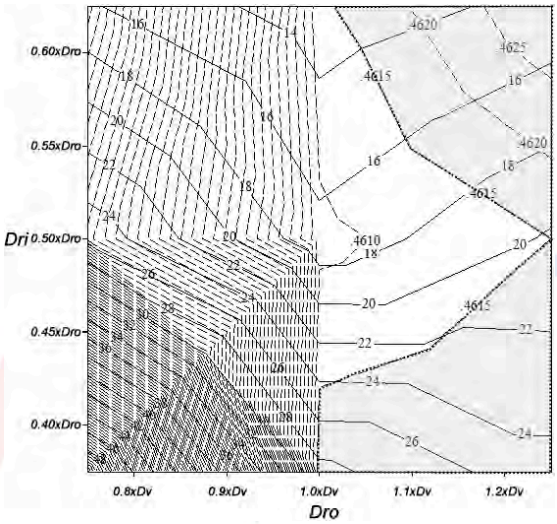


(a) Vertical flow bed (b) Radial flow bed

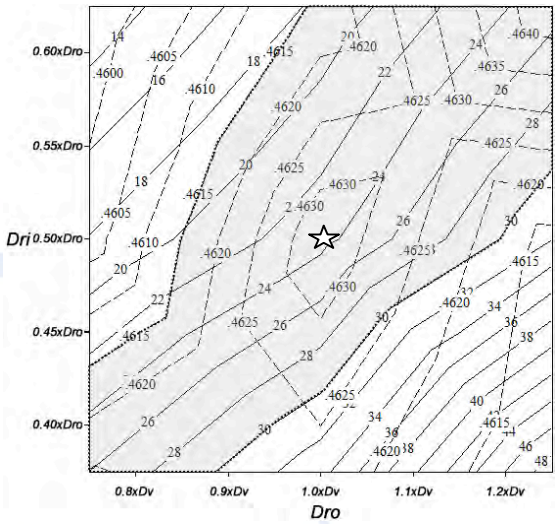
Fig. 3 Contours of pressure and humidity ratio with bed diameter 0.35 m

Optimization of Designing Parameters. The purpose of optimization for the desiccant column in this study is to find the optimal values of designing parameters, the inner diameter and the outer diameter of radial flow bed, in order to minimize the value of the pressure drop and maximize the value of the adsorption rate. The graphical optimization technique was adopted. For diameter of the vertical flow bed being 0.20, 0.30 and 0.40 m, the contour plots were superimposed and the regions that best satisfied which the pressure drop less than 30 Pa and the adsorption rate more than 0.4615 kg_w/h. The overlapped area between the inner diameter and the outer diameter of radial flow bed shown in Fig. 4 could be recommended as satisfied zone. The solid line, dash line and overlapped contour plots were referring to pressure drop, adsorption rate and satisfied zone, respectively. For this study, the satisfied zone of the radial flow bed with D_v

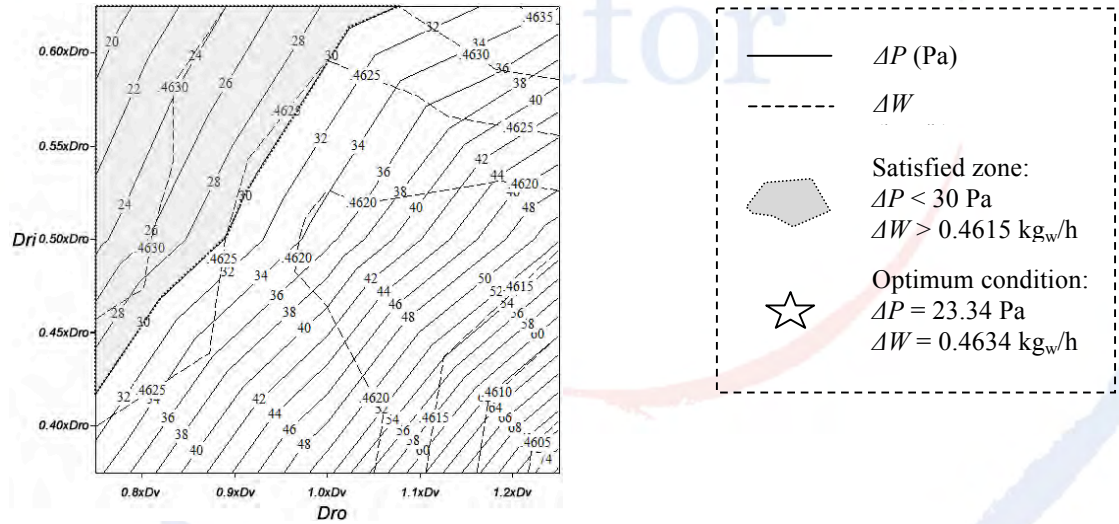
0.2 m was found inner diameter and outer diameter between 0.08 m to 0.16 m and 0.20 m to 0.25 m, respectively (Fig. 4a). In the radial flow bed with D_v 0.3 m, the satisfied zone was found inner diameter and outer diameter between 0.08 m to 0.23 m and 0.22 m to 0.38 m, respectively (Fig. 4b), whereas the satisfied zone of the radial flow bed with D_v 0.4 m was found inner diameter and outer diameter between 0.13 m to 0.26 m and 0.30 m to 0.42 m (Fig. 4c). Finally, the practical optimum condition (star symbol in Fig. 4b) is the inner diameter 0.15 m and the outer diameter 0.30 m. As a result, the feasible and optimum condition values are 23.34 Pa and 0.4634 kg_w/h.



(a) Radial flow bed with D_v 0.2 m



(b) Radial flow bed with D_v 0.3 m



(c) Radial flow bed with D_v 0.4 m

Fig. 4 Superimposed contour plots showing the shaded overlapping area for which $\Delta P < 30$ Pa and $\Delta W > 0.4615$ kg_w/h

ANOVA Analysis. The test for significance of the regression model and the test for significance on individual model coefficients need to be performed for reliability of the prediction model obtained. Through the backward elimination process, the final fitted regression models of the pressure drop and the adsorption rate of radial flow bed with D_v 0.2, 0.3 and 0.4 m in terms of the inner diameter and the outer diameter are presented in Table 2. The effect examinations of model coefficients for radial flow bed with D_v 0.3 m are tabulated in Table 3. A less probability value (P-value) suggests that the influence of the factor is significant. It shows that the probability values for those terms are lower than 0.05. Therefore, the influential degree of the factor is higher than the 95% confidence level.

Table 2 Regression models of radial flow bed

Regression models	Units
For D_v 0.2 m	
ΔP = 270.299-305.045×D_{ro}-270.825×D_{ri}+93.990×D_{ro}×D_{ro}+191.055×D_{ro}×D_{ri}	Pa
ΔW = 0.052- 0.582×D_{ro}-0.323×D_{ri}-0.196×D_{ro}×D_{ro}-0.275D_{ro}×D_{ri}	kg_w/h
For D_v 0.3 m	
ΔP = 45.483+54.228×D_{ro}×D_{ro}-239.036×D_{ro}×D_{ri}+169.067×D_{ro}×D_{ri}×D_{ri}	Pa
ΔW = 0.470-0.052×D_{ri}-0.115×D_{ro}×D_{ro}+0.052×D_{ro}×D_{ri}	kg_w/h
For D_v 0.4 m	
ΔP = -51.973+175.119×D_{ro}-234.085×D_{ro}×D_{ri}+126.978×D_{ri}×D_{ri}	Pa
ΔW = 0.471-0.012×D_{ro}-0.012×D_{ri}+0.019×D_{ro}×D_{ri}	kg_w/h

Table 3 ANOVA table for the pressure drop and the adsorption rate of radial flow bed with D_v 0.3 m (after backward elimination)

Pressure drop, ΔP (Pa)

Term	Coefficient	Standard error coefficient	T-ratio	P-value
Constant	45.483	7.312315	6.220074	0.001570
D_{ro}×D_{ro}	54.228	7.513510	7.217365	0.000796
D_{ro}×D_{ri}	-239.036	61.678333	-3.875532	0.011695
D_{ro}×D_{ri}×D_{ri}	169.067	61.629797	2.743273	0.040634

Standard error	= 1.534078	R^2	= 0.987413
Coefficient of variation	= 5.793317	R^2 adjusted	= 0.979862
PRESS	= 47.619197	R^2 for prediction	= 0.949064

Adsorption rate, ΔW (kg_w/h)

Term	Coefficient	Standard error coefficient	T-ratio	P-value
Constant	0.470	0.003590	132.080000	0.000000
D_{ri}	-0.052	0.012780	-4.067000	0.009660
D_{ro}×D_{ro}	-0.115	0.003180	-3.606000	0.015440
D_{ro}×D_{ri}	0.052	0.012490	4.138000	0.009020

Standard error	= 0.000828	R^2	= 0.811000
Coefficient of variation	= 0.179000	R^2 adjusted	= 0.697000
PRESS	= 0.000011	R^2 for prediction	= 0.401000

Conclusion

In this paper, the designed parameters of the desiccant column have been proposed. The simulations were performed by use of the commercial finite volume flow solver Fluent on ANSYS version 13.0 software. The total mass of silica-gel in the bed being 10 kg, column volume of 0.045 m^3 and air ventilation of 26 kg/h were used in the simulations. As a brief summary, the main findings can be summarized. For one thing, increasing the vertical flow bed diameter decreases the pressure drop within the column and varies the adsorption rate around 0.4615 kg_w/h, and increasing the radial flow bed diameter rises the pressure drop and the adsorption rate simultaneously. Finally, the practical optimum zone of the inner diameter and the outer diameter is equal 0.15 and 0.3 m, respectively; as a result, the feasible and optimum condition values are 23.34 Pa and 0.4634 kg_w/h. For acceptable of the prediction model, the test for significance of the regression model and the test for significance on individual model

coefficients need to be performed. It shows that the probability values for those terms are lower than 0.05. Therefore, the influential degree of the factor is higher than the 95% confidence level.

Acknowledgements
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Evaluation of Greenhouse Gas Emission from Residential Buildings in Thailand

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Abstract:

The energy consumption in the residential building sector is one of the main sources of greenhouse gas emission. The greenhouse gas (GHGs) emission is contributed from the life cycle of the residential building: the manufacturing of construction materials, construction process and residential phase. This research studied the energy consumption and greenhouse gas emissions from the residential phase compared with those from construction materials and construction process. The Energy Plus software was applied to calculate the electricity uses during the residential phase of 25 years. Greenhouse gas emission was then calculated using the Thailand electricity emission factor. Three house styles such as modern, contemporary and Thai-modern styles and four different building envelopes made from wood, concrete, lightweight concrete and brick were comparatively studied. Clearly, brick house was the majority of GHGs emission due to energy consumption, accounting for 626.52 $kgCO_2e./m^2$ whereas lightweight concrete, concrete and wood house contributed 603.20, 576.15 and 486.69 $kgCO_2e./m^2$ respectively. The result indicated that wood, which has low thermal mass material, was the promising material for the reduction of GHGs emission associated with electricity use during residential phase.

Keywords:Greenhouse Gas Emission, Energy Consumption, Residential Building, Residential Phase

I. Introduction

Energy crisis and global warming likely increase in recent years. The Intergovernmental Panel on Climate Change (IPCC) reported that the residential building sector contributed approximately 7.9 % of total energy consumption in 2007, which were mainly from electricity consumption [1]. In 2010, Thailand Energy Statics reported that the energy consumption from residential sector is 15.5 % of total final energy consumption [2].

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Most of electricity consumption was released from lighting, air-conditioning and equipment system. Increasing of population has become a major concern in residential construction. According to the Bangkok housing market, the house construction during the year 1990 – 2009 was dramatically expanded. The single-detached house and duplexes shared the highest volume up to 39.5 % of total completed houses [3]. Housing construction caused the greenhouse gas emission from building materials manufacturing and construction process. Nowadays, there are a variety of construction methods and materials such as precast concrete, lightweight concrete, bricks, synthetic wood etc. Considering the residential phase, GHGs emission comes from the energy consumption such as fuel and electricity. The electricity, the major contribution, is commonly consumed in home electrical appliances, cooling and lighting system. But the proportion of electricity used for cooling purpose was the most, up to 79% as shown in Fig. 1. The amounts of heat loss and heat gain bring about the difference in cooling load which directly reflects to the electricity consumption. Figure 2 presents the heat sources in the residential building. It is obviously seen that most of heat comes from the building envelop (94%), especially from wall. Thus, materials for building envelop manufacture play an important role to reduce the consumption of the electricity as well as GHGs emission.

In Thailand, there is a study of the main energy consumption in buildings. During the materials manufacture, concrete and steel were the most significant elements leading to the highest embodied energy, which contributed 35 % and 42 %, respectively. While the residential phase accounted for 81% of total energy consumption. Air conditioning used in residential phase remains the major share of energy about 56 % of the end use electricity [5]. This result indicates that the residential phase is a main factor influencing the performance of energy consumption and causing adverse impacts to environment.

Energy Plus is an energy analysis and thermal load simulation program. Based on a user's description and perspective of the building, the building model plug in with simulation of heating and cooling can be desired. This program can calculate the heating and cooling loads necessary to maintain thermal control set points under desired conditions throughout heating, ventilation, and air conditioning (HVAC) system and coil loads. Moreover, the program can evaluate the electricity consumption presented in the unit of kWh/m^2 per year [6]. A recent research constructed a model to compare an energy performance of a steel-frame house and a wood-frame house with a conventional concrete-frame house by Energy Plus. The results show that the wood-frame house and steel-frame house consume less energy than the concrete-frame house [7].

The aim of this research is to evaluate GHGs emission from energy consumption during residential phase using Energy Plus simulation software and compared the results with other studies.

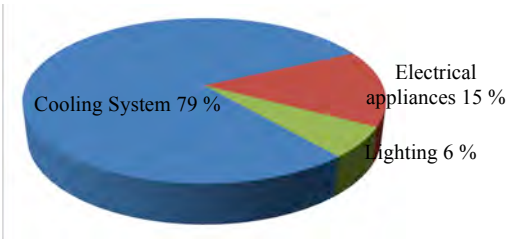


Fig. 1 Housing energy consumption [4]

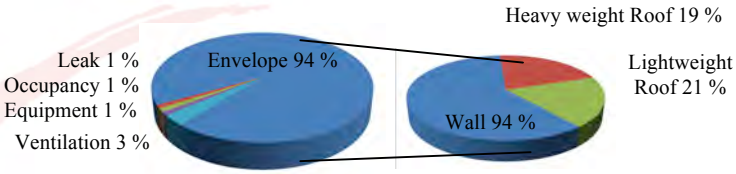


Fig. 2 Heat sources within the residential building [4]

II. METHODOLOGY

The simulation was focused on four different wall materials including brick, lightweight concrete, concrete and hardwood being used as main construction materials for four different home styles including contemporary, modern and Thai-modern style as shown in Fig. 3. The floor plans are shown in Fig. 4 and represent those that were extracted from 42 surveys of current house styles in Bangkok area. Then, the Energy Plus program was employed to perform energy simulation for the models. Based on Thailand weather database, the house models used for the simulations were assumed to be located in the Bangkok, Thailand (14 °N latitude). The dwelling activity and occupancy data are presented in Table I. The electrical appliances or and lighting energy are set to 8 W/m^2 and 7 W/m^2 respectively. [8] The house is cooled by HVAC system which is a constant volume direct-expansion (DX) type and it operating set point temperature was 25 °C. Only wall materials component such as brick, lightweight concrete, concrete and hardwood were considered from software database as shown in Table II

The calculation of GHGs emission from electricity use was followed Tier I, The Intergovernmental Panel on Climate Change guideline (2006) [9]. The GHGs emission was calculated by multiplying 0.561 kgCO_2/kWh (Emission Factor of Thailand Electricity Production) [10] with the amount of electricity consumed.

Fig. 3 Thai residential types

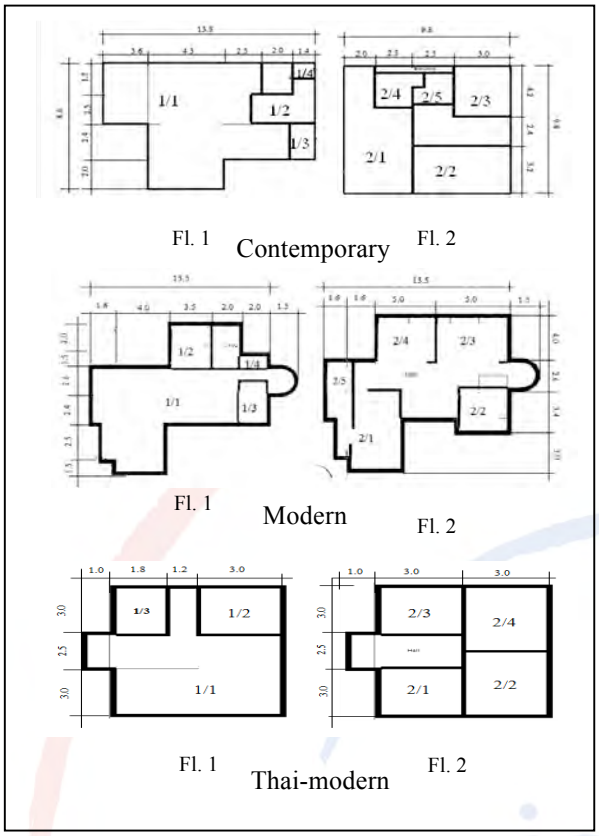


Fig. 4 General floor plan

TABLE I
ZONE SUMMARY

Contemporary Total Area 192.48 m^2				Modern Total Area 227.98 m^2				Thai-modern Total Area 163.86 m^2			
Room	Area (m^2)	People /m^2	Air	Room	Area (m^2)	people /m^2	Air	Room	Area (m^2)	people /m^2	Air
1/1	71.24	0.04	N	1/1	69.08	0.06	N	1/1	34.21	0.07	N
1/2	9.53	0.22	N	1/2	10.2	0.14	N	1/2	9	0.2	N
1/3	3.83	0.28	N	1/3	6.81	0.2	N	1/3	5.26	0.18	N
1/4	1.4	0.89	N	1/4	2	0.2	N	2/1	8.4	0.1	Y
2/1	34.44	0.05	Y	2/1	27.94	0.05	Y	2/2	11.34	0.15	Y
2/2	22.42	0.08	Y	2/2	11.61	0.07	Y	2/3	11.34	0.15	Y
2/3	13.67	0.07	Y	2/3	17.5	0.05	Y	2/4	8.73	0.1	Y
2/4	7.29	0.14	N	2/4	14.05	0.1	N				
2/5	5.53	0.18	N	2/5	3.97	0.19	N				

TABLE II
THERMAL BULK PROPERTIES OF MATERIALS

Materials	Thickness (m)	Conductivity (W/m.K)	Density (kg/m^3)	Specific Heat (J/kg.K)
Brick	0.1	0.84	1,700	800
Concrete	0.1	2.3	2,300	1,000
Lightweight Concrete	0.1	0.74	600	840
Mortar	0.01	0.72	1,650	920
Wood	0.03	0.8	90	2,810

III. Results

While assuming all parameters used in the simulations constant except construction, the simulations showed the strong dependence of energy consumption, especially in the air-conditioned room of the contemporary style, on types materials as shown in Fig. 5. It is indicates that the house with low thermal mass such as wood reduces the energy consumed by cooling system when compared to ones with higher thermal mass such as concrete, brick and lightweight concrete.

This is due to the fact that high heat absorbed in the higher thermal mass materials constitutes higher cooling loads when the air-conditioners are on during the dwelling time.

In addition, the house constructed by wood not only reduces the inside temperature quicker but also reduce the energy required for air conditioning system used during nighttime occupancy. Fig. 6 illustrates the energy end uses in the unit of kWh per year from equipment, lighting and cooling due to each type of house materials.

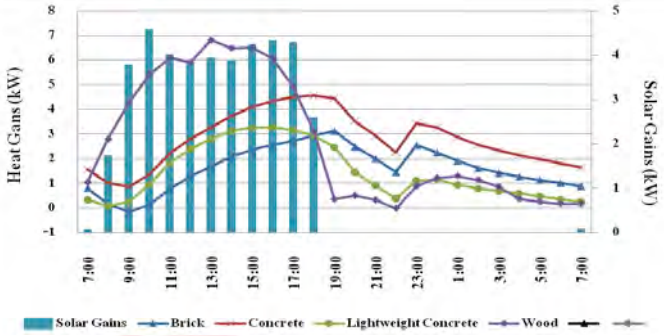
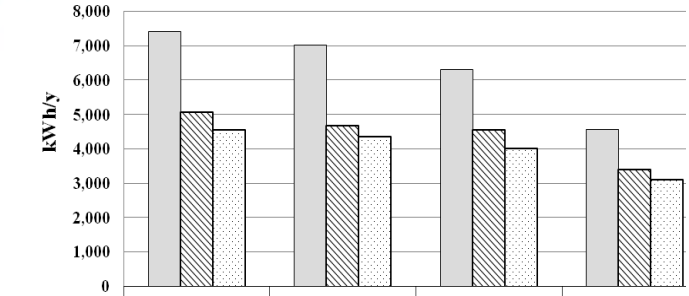


Fig. 5 Heat gain due to each type of wall materials (Contemporary)



	Brick	Concrete	Lightweight Concrete	wood
Modern	7,401.28	7,008.89	6,316.73	4,575.47
Contemporary	5,079.30	4,676.28	4,550.90	3,417.58
Thai-modern	4,557.86	4,365.30	4,021.69	3,102.31

Fig. 6 Energy end uses due to each type of house materials

Energy end uses due to each type of house materials were shown in Fig. 6 Electricity consumed by the modern type was the most because of its construction without the pitched roof for that could prevent heat from entering into the building. This causes the higher energy consumption compared to contemporary and Thai-modern. The energy end uses for equipment and lighting of each housing types were the same value as occupancy templates were kept constant for all case studies. Each simulation compared the effect of wall materials on energy use and it was found that brick and concrete was the main energy consume more than lightweight concrete and wood respectively. This energy can be further associated with CO_2 emission from electricity generation.

To evaluate the impact of global warming on the energy consumed during residential phase, the most effective energy end use is cooling system. Fig. 7 presents the GHGs emission from calculation of energy (electricity) used for cooling load. This figure indicates that air conditioning system consumption in the wood structured house contributed to the smallest share of GHGs emission.

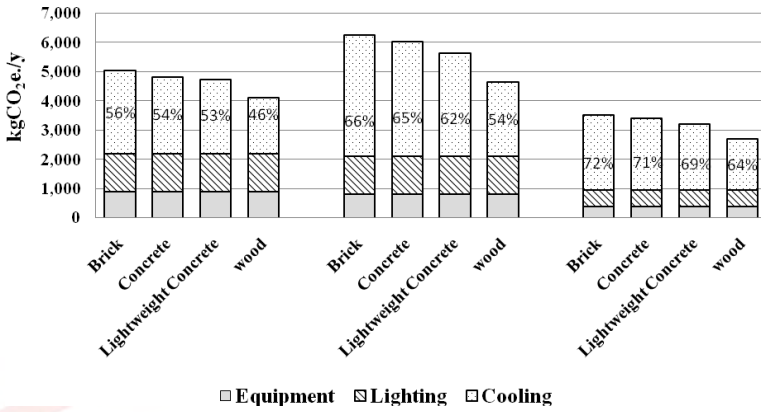


Fig. 7 GHGs emissions from energy consumption

Considering the amount of CO_2 emission from building wall materials, the lowest CO_2 from Contemporary type is wood structure which reduces to 46 % of cooling system. As the amount of emission can be reduced by Modern wood type is about 54 %, while the minimum CO_2 of Thai style remains the wood envelope, approximately 64 %. Clearly, using the low thermal mass influences the energy required for cooling electricity and this energy can contribute to reduce GHGs emission more than using high thermal mass such as brick or concrete. Therefore, it is suggested that the residential construction be considered the appropriate materials selection which can reduce energy used and GHGs emission.

There is a study of GHGs emission from construction materials manufacture and process for residential building in Thailand comparing to the GHGs emission from 3 phases; materials, construction and use phase base on an assumed life time of 25 years was presented in Table III

TABLE III
GHGs EMISSION COMPARING 3 PHASES

Phase	GHGs emission comparing 3 phases ($kgCO_2e./m^2$)				
	Brick	Concrete	Lightweight Concrete	Wood	Ref.
Materials	212.33	233.23	191.55	2.47	[11]
Process	3.28	4.28	3.7	1.95	[11]
Occupancy	626.52	603.2	576.15	486.69	This research
Total	842.13	840.71	771.4	491.11	

According to the emission from 3 phases, house constructed by brick was the highest emission about 75 % related to energy consumption during 25 years includes energy use for lighting, equipment and cooling system which is the main energy requirement. 24.99 % was from material manufacture and construction process was the lowest source of emission. Concrete and lightweight concrete were the next source of emission account for 70.98 % and 75.98 % respectively. 29 % and 24 % were from materials. The emission from construction was also the minimum source. During the occupancy of house constructed by wood (Thai-modern) contributed the smallest source of emission about 99 % and only 1 % from material which wood was the carbon storage in (Sink and Source) Moreover, wood as the lower thermal capacity than other materials can reduce the energy use of cooling system and effect on the GHGs emission.

IV. Conclusion

The thermal mass property of wall materials directly related to energy consumption within residential building. The result would indicate that low thermal mass such as wood consumed less energy than other high thermal mass such as concrete or brick. The simulated energy is also associated with the global warming potential during residential phase. This result can provide the important information of building materials which affect for the material selection awareness and may be used as a guideline to reduce greenhouse gas emission from residential sector.

Acknowledgment

The authors thank National Research Universities (NRU) and Office of the Higher Education Commission, Thailand for financial support.

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Impacts of Climate Change and Adaptation Policy: The Case of Thailand

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Abstract:

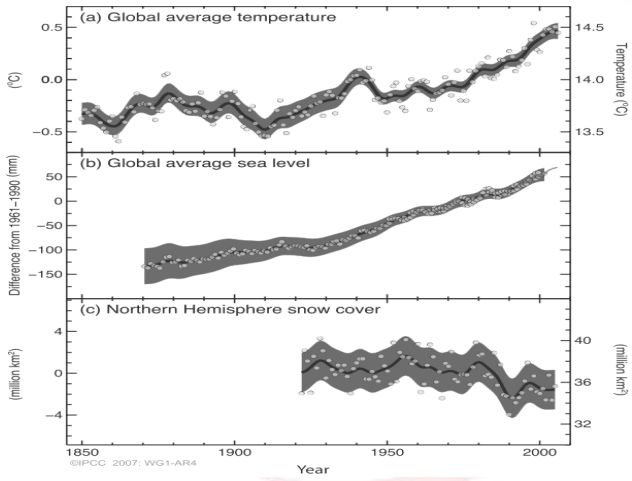
Climate change and increasing global temperature bring about extreme weather events including floods, droughts, landslides, and strong storm surges. These extreme events have become more frequent and damaging as well as increasing the loss of forests and farmlands. In addition, rising sea levels are threatening coastal communities, and infectious diseases such as dengue and malaria is increasing. This paper reviews the literature of the impact of climate change and analyzes the adaptation policies in Thailand focusing on five main sectors; agriculture, water resources, forestry and ecosystem, coastal and marine resources, as well as human health. After analyzing empirical evidence and observing the practices of adaptive actions, we find that although Thailand already has many useful adaptation policies, it still has many problems. In the case of the devastating flood of 2011, despite there being enough time and good recommendations from experts to prepare for the disaster the country did not minimize and control the damage from the inundation. It can be concluded that in Thailand, the government should play a major role in providing incentives and pursue effective policies for individuals and organizations to adapt to climate changes. In particular, it is most necessary to develop practical early warning systems and useful instruments to reduce risk from climate change. For example, index base insurance was created to help smallholder farmers in agriculture. Finally, the government needs to prioritize education and research into climate change and formulate adaptation plans, together with managing central data and administrative systems.

1. Introduction

The causes of global warming can be separated into natural systems and human activities whilst the main real causes are still debated widely. Nevertheless, in this paper, we follow the Intergovernmental Panel on Climate Change (IPCC) approach because around 98 % of climate researchers think people are causing global warming. The IPCC emphasizes adaptation and mitigation to deal with the impacts of climate change (results of global warming) in order to create sustainable development and simultaneously reduce poverty. This approach, rather than just focusing on seeking the origins are much more helpful for developing countries to plan for the future (Anderegg, William R L; Prall, Harold, and Schneider, 2010).

As the earth is warming, the climate is unavoidably changing. Climate change is a fact and an urgent challenge that has already affected people and the environment worldwide. Both human activities and natural systems contribute to climate change[1]. Major changes are happening to the earth, including increasing air and ocean temperatures, widespread melting of snow and ice, and a rise in average global sea levels. Climate change is occurring now, and the effects are emerging everywhere both in continents and oceans (IPCC, 2007). Figure 1.1 demonstrates trends of higher global average temperatures, rising global average sea levels, and decreasing Northern Hemisphere snow cover respectively.

Figure 1.1: Changes in Temperature, Sea Level Rise, and Northern Hemisphere Snow Cover



Source: IPCC (2007)

Thailand is a part of Southeast Asia and has a fast-growing economy. Since it possesses long coastlines, a high percentage of the population participates in economic activities relying on access to the sea. Agriculture plays a crucial role in providing livelihoods for a large segment of the population, especially those living with poverty (who might be considered unskilled labors in industrial sector). Furthermore, the Thailand economy also relies upon natural resources and forestry to drive development as seen by the fact that agriculture contributed to a significant proportion - about 10.7 % of GDP - in 2006 and accounted for 42.3% of the country's employment in 2004.

Thailand is confronting many massive negative impacts of global climate change, including prolonged flooding. The trend of increasing natural disasters causing losses of forests and

[1] Human causes include burning fossil fuels, cutting down forests, and developing land for farms, cities, and roads. These activities all release greenhouse gases into the atmosphere; Natural causes include changes in the Earth's orbit, the sun's intensity, the circulation of the ocean and the atmosphere, and volcanic activities (EPA, 2010).

farmlands, rising sea levels, and is threatening coastal communities and a surge in infectious diseases such as dengue and malaria. Thus, Thailand could be considered highly vulnerable to the harsh impact of climate change.

For this reason, this paper will review and analyze the current adaptation policies in Thailand, and provide recommendations for anticipated adaptation policies in order to efficiently deal with the impact of climate change. The approach of this study is to review and analyze through an in-depth review of studies, stylized fact as well as evidence and summarize the current impact of climate change. The focus is on the main sectors, which are water resources, agriculture, forestry and ecosystem, coastal and marine resources, and human health, as well as the recent floods with the existing adaptation policies in Thailand. In the final part, we will suggest anticipated adaptation policies to the next changing climate in Thailand.

2. Current Status of Climate Change and Impacts in Thailand

Thailand has an overall area of approximately 514,000 km^2. As it is located in the tropics its climate is relatively warm throughout the year. It can be separated into four spatial classifications: central plains; valleys in the north; plateaus in the northeast and southern plain areas. It is estimated that the population will expand from 63.4 million in 2008 to more than 71 million in 2028 (National Economic and Social Development Board, Population forecast for Thailand, 2000-2030, October, 2007). With this population size, the risks of climate change must be addressed at an early date. Thailand is projected to warm up during this century, accompanied by the global trend of mean surface air temperature that tends to be also on the increase. The Maplecroft report in 2010 indicated that Thailand was ranked 14th among other 170 countries worldwide which will be most vulnerable to climate change in the next 30 years. This can be supported by the practically observed and projected climate change as represented in Table 2.1.

Table 2.1: Evidence of Observed and Projected Climate Change in Thailand

Evidences / Results /Suggestions	**Research / Worked by**
Temperature in Thailand continues to increase, ranging from 0.10 to 0.18°C per decade over five decades of observation.	Snidvongs, 2006
Based on the climate data generated by a global circulation model, by the end of this century Thailand's temperature is projected to increase 2 to 4ºC.	Thailand Environment Institute (TEI), 2000
At some time in the past, Thailand has experienced an average daytime temperature up to 40°C, especially during the month of April.	Jesdapipat, 2008
Compared to the first half of the last century, annual rainfall in Thailand has declined in the past 3–5 decades.	Jesdapipat, 2008
There will be a shift in precipitation from north to south annually in Thailand.	TEI,1999 Boonyawat & Chiwanno, 2007
Extreme weather events in Thailand consist of prolonged floods, droughts and landslides, as well as strong storm surges. These extreme events have become more frequent and damaging. While, storms have become more intense but so far not more regular.	Jesdapipat, 2008
During the 20th century, the sea level increased at an average rate of 4.8 to 8.8 inches per century (1.2-2.2 mm/year). Thailand is experiencing above-average sea level rise.	IPCC, 2007

In Bangkok, the capital of Thailand subsided by up to two meters over the twentieth century.	Milliman & Haq , 1996 IGES, 2007
Thai gulf side is more vulnerable for sea level rise. Bangkok area experienced over pumping of ground water, land subsidence occurred, which was relative to sea level rise.	Furukawa & Baba, 2002
Thailand should build a 100 kilometer seawall along the Gulf of Thailand to reduce the risk of massive floods.	Dijkgvaaf, 2010

Source: Collected by author (2012)

2.1. Impact of climate change on water resources

A few decades ago, the evidence of studies disclosed that Thailand had plentiful water resources. However, with the onset of climate change, a problematic annual water balance has become an increasingly critical one. The quantity and quality of water resources have been affected by changes in rainfall patterns and the frequency and intensity of rainfall from some watersheds (for instance, Chaophraya Basin) down to rivers and river mouths (Jesdapipat 2008).

In Thailand, particularly the Chao Phraya River, there can be seen the effects not only of climate change but also of human activities. The river flows too high during the rainy season, but too low rates during dry seasons. In most areas of Bangkok, heavy pumping of ground water has resulted in land subsidence and in ground water contamination with saline intrusion, nitrates, coliform bacteria and volatile organic compounds (Bangkok Metropolitan Authority :BMA, 2009).

In 2001, around 920,000 households were affected by floods, while economic losses could be counted more than $1.75 billion arising from floods, storms, and droughts in the period between 1989 and 2002. Furthermore, almost all of the total losses came from the agricultural sector where crop yield losses amounted to more than $1.25 billion during 1991–2000 (Amadore, 2005a). In addition, the rising sea levels have sped up saline water intrusion and soil salinity in the region's agricultural areas, generating deterioration in potential production and considerable loss in arable lands.

2.2. Impact of climate change on agriculture

According to the report of the Ministry of Agriculture and Cooperatives, a total of 51.4 million hectares of Thailand is used for agriculture, relatively constant at about 40% during the period 1987-2005. The shift in land use from annual crops to perennial crops resulted from changes in the climate and market conditions. The more frequent droughts strongly influenced farmers in turning to produce fast-growing trees for the paper industry. Additionally, high prices of rubber and palm oil persuaded farmers, especially in the south and northeast, to use their land to plant these two crops. It is important to note that suddenly changing from annual to perennial crops makes it difficult to adjust to unexpected events, and hence exposes them to be more vulnerable to climate change.

Apart from climate, land degradation and infertile land are the causes of risks that force farmers to change the pattern of agricultural land use. Additionally, the report of the Office of Agricultural Economics, and the Ministry of Agriculture and Cooperatives revealed that soil quality is one of the major concerns; more than half of the agricultural area in Thailand has saline, sandy or acidic soils. Therefore, these areas give low growth rate of productivity. For small farmers, it is difficult to improve their soil and then it is hard to adjust to climate change.

In Thailand, agricultural activity contributes around 11.4% of the total Gross Domestic Product (GDP). Rice is the most important of the agricultural commodities; while other significant products include rubber, fish and fisheries, tapioca, grain, and sugar.

Because of lack of understanding on the prospects of climate change, droughts and floods can cause food scarcity and new disease outbreaks, affecting production (Boonprakrob and Hattirat, 2006). Due to anticipated sea level rises, aquaculture, which is one of the most important export products of Thailand, will be most affected. Therefore, the agricultural sector of Thailand is most vulnerable a concern that needs to be taken care of immediately.

2.3. Impact of climate change on forestry and ecosystems

Forest areas in Thailand have gradually decreased and were simply relatively stable only in the 1990s due to strong measures implemented by the Thai government; in particular those that banned logging and expanded forest conservation areas. In the early 2000s, forestland was redefined and wooded areas were adjusted accordingly (Royal Forest Department, 2005).

In 2004, Thailand's forest areas of 16.8 million hectares accounted for about 33% of the total land area. Most of the forest areas are in the northern and western parts of the country, although there are some along the southern peninsula. Northeast Thailand has the least conserved forest areas of all (figure 2.2).

Figure 2.1: Forest areas Distribution in Thailand, 2004

Source: Department of National Parks, wildlife and Plant Conservation (2007)

In recent years with the impact of climate change, the prolonged and hotter dry season, the diminishing in rainfall and the availability of combustible herbaceous fuels have spurred the spread of forest fires, which have added enormous environmental and economic damage. In the monsoon season, heavy rains and tropical cyclones have also caused massive landslides in already degraded forest areas, damaging livelihoods and endangering lives. Climate change has negatively affected the daily life of people all year round.

Due to climate change, rising sea levels and coastal erosion are affecting many mangrove forests of Southeast Asia including Thailand (ADB, 2009). Increasing sea levels linked to global warming have threatened economically, ecologically, and culturally important mangrove forests in the region (Gilman, 2006). These mangrove forests, which act as protectors against storm surges and coastal erosion, have been shortened in size by rising sea levels and by the damaging impact of coastal erosion. Bang Khun Thian, which is Bangkok's only seaside district and which once comprised five kilometers of muddy coastline with plentiful mangrove forests as well as rare and various species of plants and marine life, has lost more than 483 hectares of mangrove forests over the last 30 years. These studies all insisted that forestry and ecosystems have been badly affected by climate change. Adaptation policies may be a solution to the problem.

2.4. Impact of climate change on coastal and marine resources

More than 30,000 households in more than 64,000 hectares in Southeast Asia have economic activities depending on coastal aquaculture and marine resources, for example earning their living from shrimp farming and seashore fishing. However, in recent decades, all coastal lands and marine resources in these areas have been affected by global warming, extreme events, and increasing sea levels (Table 2.3). The high temperature of under seawater of April 1998 brought about outspread coral bleaching in the Gulf of Thailand from the south (Narathivat province) and east (Trat province), up to the inner part of the Gulf (Chonburi province) (ADB, 2009).

Table 2.1: Summary of Observed Impacts of Climate Change on the Coastal and Marine Resources Sector in Thailand

Climate Change	Observed Impacts
Increasing temperature	– Increased coral bleaching and degeneration of coral reefs particular in Phuket Island Thailand in 1979, 1981,1998
Variability in precipitation (including El Niño Southern Oscillation)	– Increased loss of land due to erosion and flooding of coastal areas Example along the coasts of Andaman and The Gulf of Thailand. Almost 600 km of the shoreline is confronting severe coastal erosion. Erosion rate in some areas is greater than 25 m/yr. – Increased damage from floods and storm surge including damage to aquaculture industry
Sea level rise	– Accelerated salt water intrusion inland

Source: Adapted from ADB (2009)

Thailand's seashore totals 2,667 km covering twenty-three coastal provinces along the Andaman and The Gulf of Thailand. Almost 600 km of the seashore has been severely threatened by coastal erosion, for instance in some areas, the erosion rate is greater than 25 m/yr. Thus, coastal erosion is a major problem along the Gulf of Thailand from the east (Trat province) to the south (Narathiwat province). For example, the small coastal village of Khun Samutchine in Samut Prakan province in the south of Bangkok has been reported as a serious case though it once used to have a wide variety of natural habitats, including wetlands, mangrove forests, and plentiful flora and fauna.

Wassmann et al., 2004 and Stern, 2007 revealed interesting information that by 2100 the global mean sea level is predicted to increase by 40 cm, which could mean a rise in the average annual number of people affected by floods within coastal regions, or from 13 million to 94 million people worldwide. About 20% will live in Southeast Asia, particularly in Indonesia, The Philippines, Thailand and Viet Nam. This may be unavoidable; however, as it has not yet arrived we can still adapt and change to survive by creating sustainable development through cooperation at both local and global levels.

2.5. Impact of climate change on human health

Climate change can affect numerous aspects of the environment and, subsequently, human life and health (Table 2.4). Higher temperatures and appearance of climate change lead to an higher level of air pollution, multiply transmission of diseases through unclean water and contaminated food, as well as an increasing problem of inadequate shelters for the poor due to an increasing number of disasters from floods and storms (UNFCCC, 2007; WHO, 2008; Hutton, 2011).

Furthermore, similar to developing countries in Southeast Asia, Thailand has many of the region's poor who live in coastal areas and in the low-lying deltas. These people are usually fishermen, smallholder farmers, and poor households who are the most vulnerable to risk of climate change. They do not have enough income to procure good health services or maintain other safety systems against extreme changing conditions. Some plausible direct intimidations that climate change could pose on human health in Thailand include morbidity and mortality caused by thermal stress (heat stress); vector-borne diseases (for instance, malaria and dengue); water-related diseases like diarrhea and malnutrition (ADB, 2008). What is more, sometimes climate change can be the cause of injury and deaths, in consequence of landslides, flashfloods, and tropical cyclones. Past studies indicate that Thailand has had an increasing trend in dengue cases since 2000 (NESDB, 2007; Jesadapipat, 2008).

Table 2.2: Health Impacts of Climate Change: Classification

Climate impacts	**Health impacts**	
	Direct	**Indirect**
Temperature extremes (Heat or cold waves).	Heat- and cold-related stresses	- Respiratory and cardio-vascular diseases due to the combined effect of exposure to high temperature and air pollutants
Extreme weather events		
Floods, landslides, storms, cyclones	Deaths and injuries	- Water-borne diseases caused by water contamination and poor sanitation conditions - Psychological morbidity
Droughts	-	- Malnutrition and under-nutrition, due to loss of agricultural production - Water-borne diseases caused by decreased water access and malnutrition - Vector-borne diseases due to changes in vector transmission and stagnation/contamination of small rivers and drainage canals - Respiratory diseases due to increased air-borne particulate matter and increased vulnerability caused by malnutrition and other diseases
Increased temperature	Aggravate many chronic diseases with cardiovascular respiratory disease	- Vector-borne diseases due to higher risk of transmission and changes in the geographical and seasonal distribution - Food-borne diseases due to food contamination

Source: Adapted from Markandya A & Chiabai A (2009) and Langkulsen U, Vichit-Vadakan N and Taptagaporn S (2010)

The causes of climate change are complex and its impact is unavoidable. Being well prepared and more responsible is certainly an urgent need. Thailand therefore requires feasible climate policies and action plans to reduce the risk of disasters.

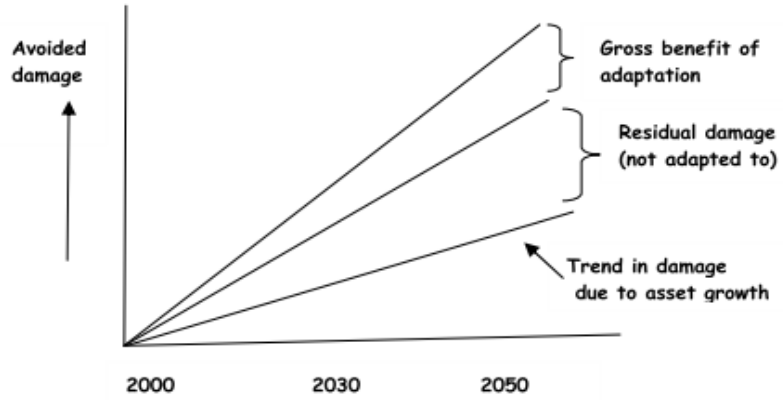
3. Costs of Climate Change and Assessment of Adaptation policies

'Adaptation is the adjustment in natural or human procedures in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation' (IPCC TAR, 2001 a)

Adaptation cost deals with cost of planning, preparing, facilitating and executing adaptation measures, as well as transition costs. We found that adaptation policies or adaptation measures are the set of organization, localization and technical changes that societies will have to implement to limit the adverse effects of climate change and to maximize benefits in domestic activities. Adaptation can act at two broad levels: building national and local adaptive capacity and delivering specific adaptation actions. We focus on the point that the impacts of climate change can be avoidable by appropriate adaptation.

The residual damages are not clearly expected (UNFCCC, 2007). However, the important characteristic of residual damages is what we must start to investigate because the amount may be significant and likely to increase over time (figure 3.2). In the UNFCCC report, residual impacts are calculated at about one-fifth of all impacts in agriculture in 2030 and, over the longer term, may account for up to two-thirds of all potential impacts across all sectors, depending on the amount of climate change not avoided by mitigation (Mc Carl, 2007).

Figure3.1: Schematic of Adaptation Costs,
Avoided Damages and Residual Damage compared over time



Source: Parry et al. (2009)

4. The Current Adaptation Policy in Thailand

There are two levels of mainstream climate change adaptation; local and global levels. The global aspect of climate change management in Thailand relates to the UNFCCC, IPCC and GEF. The Office of Natural Resource and Environmental Policy and Planning in the Ministry of Natural Resources and Environment are the national focal point for climate change. At the national level, the Ministry of Natural Resources and Environment is the one directly responsible for issues related to climate change.

4.1. Adaptation options and practices in water resources

Amid unbalancing water stress due to climate change, increasing water demand has led to a shortage of water in dry seasons, whilst an overwhelming water supply in rainy seasons has resulted in more frequent floods in most parts of Thailand. In order to improve the water imbalance situation, the government has used supply-side measures, such as water harvesting technologies and renovation of irrigation facilities, as well as demand-side measures, including promotion of efficient use of water resources and better water management practices (Table 4.1).

Table 4.1: Summary of Key Adaptation Options in the Water Resources Sector in Thailand

Practice	Reduced Impact	Scale	Reactive/ Proactive	Planned/ Autonomous	Beneficiary Sector
Rehabilitation of damaged irrigation and drainage facilities	Water shortage, drought, erratic rainfall	Local/ Sub-regional	Reactive	Planned	Agriculture
Improved flood control facilities, pumping stations, water gate	Extreme events, e.g. floods, storm surges	Regional	Proactive	Planned	Agriculture, Household, Industry
Integrated river basin, development, water catchment areas	Drought, flood, erratic rainfall pattern, water shortage	Regional	Proactive	Planned	Agriculture, Household, Industry
Conjunctive use of water, training for efficient use of water from irrigation	shortage, drought erratic rainfall pattern	Local	Reactive	Autonomous	Household, Agriculture

Source: Adapted from Jesdapipat (2008) and ADB (2009)

Since climate change has brought about extreme weather events such as floods and storm surges, flood control facilities have been installed and communities have been trained to cope with floods. Flood control and prevention facilities have been then put in place in major cities, for instance, the Bangkok Metropolitan Administration has constructed pumping stations in strategic areas of the city to control water in canals and rivers that tend to overflow during the rainy season. Water gate facilities have also been planned for flood regulators and for preventing of saline water invasion (BMA et al, 2009).

Thailand has also supported studies related to climate change. For example, a study on climate change in the Mekong river basin was performed by using one Regional Climate Scenario and concluded that there is an urgent need to study changes in the rainfall pattern in all the watershed areas by using more than three climate change scenarios (Boonprakrob and Hattirat, 2006). The study outcomes will be useful to be incorporated in the government's water management plans to maximize their efficiency, and to ensure future water availability.

Nevertheless, up until now, there are very few studies using mathematical models to assess physical property of water resources e.g. water flow conditions, element dispersion, sediment transfer and accumulation in planning water resource management. Thus, studies on biological diversity and the impacts of climate change on water resources and fresh water ecosystems using mathematical models need to be promoted further.

4.2. Adaptation options and practices in agriculture

Due to floods, storms, and droughts in 1989-2002, Thailand suffered more than $1.75 billion in economic losses. The major loss ($1.25 billion) was from crop yield losses (ADB, 2010). The unpredictable conditions that influence rice growing, for example, rainfall distribution, temperature levels and increasing types and occurrences of pests and diseases, will deepen in the years ahead due to climate change. This means Thailand can possibly see drier spells in the middle of the wet season that can damage young plants and floods at the end of wet seasons that affect harvesting. Thus, adaptation to climate change is very significant for growth of rice production in the country.

Normally, in Thailand the vulnerability of agriculture to climate change differs widely due to crops and location characteristics, the climate conditions and the ability of farmers to diversify their crops (OEPP, 2000). However, it can be said that the agricultural sector is most vulnerable to climate change, because most farmers are small landholders in rain fed areas. In addition, the transformation from cultivating annual field crops to permanent trees (e.g. rubber tree, palm oil tree) in recent years could restrict the flexibility of changing the cropping system when the climate changes, and hence becomes more vulnerable. Thus, farm-level adaptation practices are helpful in coping with climate fluctuations; particularly effectiveness can be heightened by well-organized institutions and policy support from the government. In Thailand, there are many adaptation practices in the agricultural sector (see examples in Table 4.2).

Thus, the government should play a more important role in augmenting adaptive capacity by providing public goods and services, such as weather information forecasts and development of early warning systems. What is more, another interesting issue is to develop innovative risk-sharing instruments to complement public sector efforts. In Thailand, recently index-based insurance was implemented on a pilot basis, for example, risk event (drought) - contract structure (index insurance linked to lending) - index measure (rainfall) - target (smallholder farmers) OECD (2008).

Table 4.2: Summary of Key Adaptation Options in the Agriculture in Thailand

Practice	Scale	Reactive/Proactive	Planned/Autonomous
Adjustment of cropping calendar and pattern e.g. in Ubonratchathani and widely	Local	Reactive	Autonomous
Changes in management and farming techniques in e.g. Yasothorn, etc.	Local	Reactive	Autonomous
Use of heat-resistant varieties e.g. in Samut Songkhram and widely	Local/ Sub-regional	Proactive	Autonomous
Diversified farming, inter-cropping, crop rotation e.g. in Khon Kaen and widely	Local	Proactive	Autonomous
Implementation of index-based insurance[2]	Local/ Regional	Proactive	Planned

[2] Index-based insurance is an instrument of agricultural adaptation option, which is thought to reduce moral hazard since payment and actual damage are not directly linked. As the insured party receives a payout irrespective of the losses experienced, the incentive to prevent and mitigate risk is preserved. There is no need for an assessment or verification of actual damage, so the

Development of early warning systems	Local/ Regional	Proactive	Planned

Source: Adapted from Chinvanno et al (2006), Jesdapipat (2008), ADB (2009)

4.3. Adaptation options and practices in forestry and ecosystems

The major proportion of people in Thailand depends on forests for their livelihoods and way of life. However, over the past decades, forest areas have been under deepening pressure since more areas are converted to croplands and grasslands due to the increasing demand for food and natural raw materials. Moreover, forest areas have been affected by rapidly rising temperatures, heat stress, and drought, which cause forest fires and consequently loss of tree species and degradation of forests. In turn, deforestation releases CO_2 and eliminates the potential for its sequestration. Thus, early warning systems of dry spells have been established simultaneously with awareness-raising programs to prevent forest fires, flash floods and landslides. For example, aggressive plans for reforestation (in Table 4.3) are being implemented to substitute forest resources damaged by climate change and extreme events.

Table 4.3: Summary of Key Adaptation Options in the Forestry Sector in Thailand

Practice	**Reduced Impact**	**Scale**	**Reactive/ Proactive**	**Planned/ Autonomous**
Reforestation, a forestation, improved forest management	Forest degradation, biodiversity loss	Local/ Sub-regional	Reactive	Planned/ Autonomous
Monitoring of degraded forests	Forest degradation, biodiversity loss	Regional/ National	Proactive	Planned

Source: Adapted from Jesdapipat (2008), ADB (2009)

However, the forestry sector has shown advantages of the win-win policy in Thailand. Since 2000, considerable efforts to expand forest areas have been carried out in the form of conserved forests reforestation and rehabilitation of deforest areas, and expansion of community and commercial forests. Reforested areas have been enlarged by more than 400,000 rai (64,000 hectares), in addition to the expansion of conserved forest areas. Since the forestry sector became a net sink of CO_2 in 2000, latter implementation plans of the Ministry of Natural Resources and Environment intentionally continued to effectively protect conserved forests. The established priorities are forest rehabilitation, conservation and rehabilitation of upper watersheds and degraded forestland and maintenance of commercial forests. Additionally, more than 3.1 million rai or about 500,000 hectares of mangrove forests along the coast of Thailand is planned to be protected (ONEP, 2009).

On the other hand to support the reforestation policy, we think it should have aggressive penalties and requiring approval for tree cutting, even though, the trees are on private properties, like in Europe. Because, if the country can preserve both forest areas and existing planted trees, it will be a good environment to conserve fertile soil and lands for agriculture and maintain excellent factors for plentiful rainfall to sustain water resources.

transaction costs are lowered and the speed of payout is improved. By basing contracts on publicly available information, the asymmetries associated with traditional insurance are reduced, encouraging greater participation. Furthermore, index insurance will give an incentive for greater measurement of weather patterns and the development of more sophisticated models (ADB, 2009).

4.4. Adaptation options and practices in coastal and marine resources

Coastal regions are important sources of income, trade and development. However, the risk of increasing sea levels and occurrence of extreme events could lead to catastrophic impacts if it is not well managed. Marine ecosystems and economic activities are created from the region's coastlines. In Thailand, a large proportion of the population lives in coastal areas and many of them earn their livelihoods from coastal and marine resources.

Unfortunately, recent climate change has caused negative impacts to the region's coastal and marine resources. For instance, rising temperatures have bleached coral reefs. Increasing sea levels have caused heavy coastal erosion, destruction of mangrove plantations, and flooding in many areas, especially major cities near the coast. Increasing sea levels have also affected many aquaculture industries and engendered saltwater intrusion of inland freshwater and aquifer resources. Future climate change will intensify these impacts and potentially endanger the development of the region.

To alleviate the impact of tropical storms and cyclones, mangrove conservation and plantation are a highly effective form of coastal protection. In Thailand, there is an aggressive plan for mangrove plantations as part of the national strategy for reforestation and forestation. Bang Khun Thian District in Bangkok is a good example of the erosion that destroys coastal areas in Thailand. Because of adaptation measures, farmers built stone walls, bamboo revetments and breakwaters reconstructed some parts of the pond walls/breakwaters and abandoned their water gates when they were covered by water.

Due to much more severe climate change, seashore erosion changed faster and much more aggressively. Therefore, an early warning system to evacuate people quickly is very important, when extreme events occur abruptly such as storm surge or typhoon and then huge coastal erosion might occur immediately. Thus, we think an adaptation and protection measure is also very important and to put in place early warning systems related to extreme events particularly in vulnerable areas such as the southern coast both the Andaman Sea and the seashore on the Gulf of Thailand. Some areas on the coast of the Andaman Sea already have early warning systems after the Tsunami of 2004; however, it should be better maintained and ready to use as soon as necessary.

4.5. Adaptation options and practices in human health

To make the adaptation climate policy in health successful, it requires a number of reactive measures in the health sector, while a more proactive approach, such as an early warning system, improved inspection, and awareness-raising programs are essential. Adoption of adaptation measures to vector-borne disease carried by mosquitoes, such as dengue, are under way in the region. For example, the Thailand Ministry of Health's campaigns to control dengue through advice on control and avoidance measures passed on to villagers via health workers, village leaders, and the media (ADB, 2009). Table 4.4 summarizes the key adaptation options in the health sector in Thailand, indicating the scale of adoption and types, which they are practiced.

Table 4.4: Summary of Key Adaptation Options in the Health Sector in Thailand

Practice	Scale	Reactive/ Proactive	Planned/ Autonomous
Coordination with other groups	Local/ Sub-regional	Reactive	Autonomous

Rebuilding and maintaining public health infrastructure	Local	Reactive	Planned/ Autonomous
Establish green, clean, and beautiful areas	Local	Reactive	Autonomous
Education and awareness (public information drive, capacity building)	Local/ Sub-regional	Proactive	Planned
Enhanced infectious disease control programs (vaccines, vector control, case detection & treatment)	Local/ Sub-regional	Proactive	Planned

Source: Adapted from Jesdapipat (2008), ADB (2009)

As already mentioned, the facts show that Thailand has some adaptation policies already. However, there are still some problems concerning the process of administrative management and building capable adaptations. We should notice that problems related to information systems and integrated management are significant issues that should be a concern in adaptation plans to climate change since the process cannot be done by government alone. If people in the country do not realize the potential risks of climate change that could affect their daily life, the negative effects of climate change will be then difficult to cope with. The latest event of floods in Thailand in 2011 is an example of failure in national disaster management.

5. Lessons learned from the recent enormous disaster

From August to December 2011, Thailand suffered from the most dreadful and prolonged floods in over 50 years. Damaged areas from north and northeast to the central plains covered more than 64 provinces of the total 77 provinces. The deluge killed more than 300 people and at least 14,000 factories were inundated, affecting more than 600,000 workers in industrial parks (Bank of Thailand, 2011).

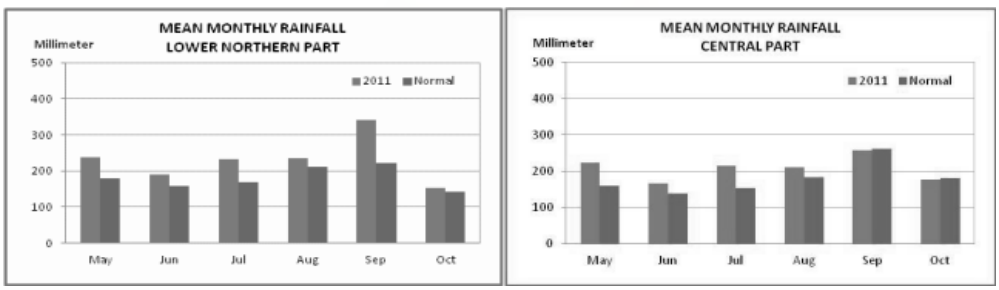
5.1. The Causes of Floods in Thailand

There are many reasons that caused the recent floods in Thailand, but the considerable factors can be divided into two approaches that are natural and non-natural factors.

5.1.1 Natural factors: There are many abnormal natural events occurring in the same time which then cause severe floods.

- From mid May until September, Thailand was threatened by several severe tropical depressions. In October, the late rainy season, the northeast monsoon prevailed over Thailand from around mid-month, associated with the high tide, severe flood and extensive damage in the lower northern part. It extended to the central part including the Chao Phraya River Basin, most areas of northern, eastern and western Bangkok and its neighborhoods. The mean monthly rainfall level compares between year 2011 and normal illustrates the outcome of the floods (Figure 5.1).

Figure 5.1: Mean Monthly Rainfall in Lower Northern and Central Part



Source: Climatological Center Meteorological development Bureau Thai Meteorological Department (2011)

5.1.2. Non-natural factors: These factors can be controlled if the country has well-organized preparedness concerning information and water management, as well as effective administrative management.

- There occurred imbalances in water resources management. For example, in normal times, the agricultural department can focus on the target of water management supporting agricultural activity only, but in the crisis it should manage and balance the water target in order to simultaneously reduce the risk of floods and damages.
- Thailand has an insufficient information system and innovation of infrastructures to protect and drain massive water inundation. Moreover, there is no effectively early warning and center of water data system. Problems concerning coordination and administrative management often exist.
- They are inexperienced concerning preparedness and risk management for disasters on this scale. The government still managed the challenges with the same procedures as in the past. Thailand's government ignored the recommendation from climate experts.
- The water management cannot be fully operated because they are always ignorance. For example, many canals and water gates are covered by plentiful water hyacinth, unwanted flora, and raffle.

5.2. Lesson learned and adaptation activities

Even though Thailand did not have sufficient innovations of infrastructures to handle the massive floods, they should perform better if they implement policies concerning awareness and preparedness. The recommendations collected from the climate researchers and experts can be summarized as follows (Global Water Partnership Southeast Asia, 2011):

- Improved adaptation strategies and assessment
- Develop and implement capacity-building and awareness raising programs
- Follow mainstream adaptation to climate change in national policy development processes
- Develop mechanisms for fund raising for climate change adaptation
- Investigate the linkages between poverty and climate change
- Develop and disseminate the improved modeling tools and finally
- Promote scientific research concerning climate change.

6. Summary and Recommendations

Global warming affects climate change and climate change affects everyone in the world. Thailand as a small country in Southeast Asia has been affected extensively. With an area of 514,000 square kilometers, population around 64.9 million and tropical climate, major economic activities and population that rely on agriculture and coastal resources are at risk from climate change. Recent studies show that Thailand will become increasingly vulnerable to climate change in the next thirty years.

Thailand is not lacking financial support but actually lacking knowledge and the ability to build an adaptation policy. Due to this problem, it is therefore necessary to set up a master plan to realize and cope with the impacts of climate change and adaptation policies immediately both in the short term and long run. Moreover, education systems should be much better in informing and training all people to build up as well as improve capacity and transfer knowledge in order to handle climate change and adaptation policies, including sustainable development in the future.

To maintain success of adaptation policies, the government has to play an important role in providing incentives and an effective policy framework for individuals and organizations to adapt to climate change and to enhance their adaptive capacity. Building and improving adaptive capacity and taking technical and non-technical adaptation actions in key climate-sensitive sectors must be an urgent priority for Thailand.

Moreover, there is also a requirement for adopting a more holistic approach to building the adaptive capacity of vulnerable groups and localities and their resilience to shocks, including developing their capabilities to transform local economies, livelihoods, and coping strategies. Finally, the country should realize the necessity of harmonized planning coordination across ministries and different levels of governmental divisions to make the resolution process go better and make climate change adaptation policies successful**.**

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Patterns and Trends in the Use of Protected Forest Resources among Rural Agricultural Communities in Benue State: Challenges and Legal Implications for Sustainable Development

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Abstract:

Benue State of Nigeria is predominantly made up of agricultural communities where agriculturalists depend on the use of forest resources. This paper examines the use of State protected forests by agricultural communities who lose access to forest produce as a result of conservation enforcement. What are the adverse implications of this on the local communities and the conservation enforcement? The objectives of this paper are therefore to (i) analyse the categories of forest products collected and conservation impact of harvesting in the study area;(ii) identify the role of protected forests resources and the impact of conservation restrictions on the income and the livelihoods of local communities; and (iii) identify the challenges and legal implications for conservation and sustainable development in the state. The method used in this paper is purely doctrinal, i.e., an analysis of the statute and related materials. The expected result is that the Benue State government should know that it has a particular responsibility to ensure that its policies and activities are consistent with contemporary or modern principles of conservation so as to adjust its policies to meet these expectations.< The conclusions drawn are that substitution for loss of income due to conservation activities would best be achieved through carefully targeted interventions to specific high-impact and high-dependency local communities. Additionally, the law must be amended to allow for a robust conservation of forest resources and sustainability that has human face.

Keywords:Forest Resources, Rural Communities, Benue State, Challenges, Legal Implications, Sustainable Development

I. Introduction

The entire world rests upon and is dependent upon the environmental resources of land, forests, water, minerals, etc. How these environmental resources are used in any given society determines or influences the health, security, economy, and the overall well being of its citizens. One of the biggest challenges facing human kind is the challenge of the survival of the Earth. The truth is, man is destroying the very system in nature that support life itself – the air we breathe, the water we drink, and the soil that produces our food. The rate of destruction is now so rapid that we risk a total breakdown of the planet's support systems in the next 30 to 50 years. For example, tropical rainforests, which contain more than half the known species of animals and plants on Earth, are a major regulator of oxygen balance in the atmosphere and exert an important control on global precipitation and moisture exchange. A little over 50 years ago, almost all of the tropical rainforests still flourished intact. At the turn of this century, we have destroyed half of those forests and the pace of destruction is accelerating. As it is, more than twenty-seven million acres of tropical forest throughout the world are destroyed each year (MacNeill; 1988:8).

The irony is that lush tropical rainforests grow on very infertile soils. Once destroyed, the forests cannot regenerate. The disaster created by desert conditions in areas such as Ethiopia where forests once thrived should sound the alarm about the fate of mankind if natural resources depletion persists in its present rate. But this is the patterns and trends in Benue State of Nigeria. Habitat destruction, hunting and felling of trees are occurring at such a rapid rate that they are fundamentally altering the ecological balance of the area. Two trends are particularly disturbing. The first is that most of the natural resources in this area – species of plant and animals – are falling into extinction. The second trend to worry about is the fact that the rapidly changing ecological condition is accelerating the desert encroachment in an alarming rate. Our appetite for energy and for chemically forcing more from the land than it can naturally give is changing the weather condition of the study area. Unlike the previous years, Benue State is yet to experience its first rain (at the time of writing this paper which is late March, 2012). This altered precipitation patterns is also affecting the vegetation of the area with potentially disastrous consequences.

Another frightening trend arising from the activities of the people is the washing away of the fertile soil. Intensive cropping, wetland drainage, slash-and-burn farming and overgrazing have dramatically increased soil erosion in this area. Such erosion is happening around Uchenyum-Ibilla, Andibilla, Okileme area, Oyinyi and Epwa-Ibilla. What does that say about our own fate? It would be the height of arrogance for anybody to assume that the human species are less vulnerable to environmental degradation than any other. We are inextricably linked to our environment, for we are what we eat, drink and even breathe. The basic question is, as plants and animals disappear from the earth, as a result of over use of the natural resources by man, what can we do to ensure a sustainable future?

Our concern in this paper is limited to exploring the patterns and trends in the use of protected forests resources in selected rural areas of Benue State and to see how best these resources can be used or managed to achieve sustainable development. A discussion on these environmental resources is necessary because any effort towards a sustainable development in all its ramifications must come to terms with either the exhaustive or non-renewable nature of these resources or their depreciation in value and to take a positive step towards not only the extraction

of these resources but also the protection of the environment, the people who live in it and the entire process of sustainable development.
In addition, forests are an essential component of livelihoods for much of the rural peasantry around the world, and research in recent years has focused on understanding and quantifying the economic contributions that forest goods, whether they be non-timber forest products (NTFPs), 'environmental services, or other forms of environmental income, make to the millions of rural households who live near forests (Byron and Arnold 1999; Belcher 2005; Vedeld, et.al, 2007). One important area of research has been to identify and classify the types of people who harvest forest produce into distinct categories by determining what they collect, how much they collect, and how dependent they are on collecting for their livelihoods, in order to help design appropriate forest management strategies (Byron and Arnold 1999; Wunder 2001; Sunderlin, et.al, 2005). This identification is particularly needed when forest users may be in conflict with protected areas and conservation plans (Salafsky and Wollenberg 2000).

Several typologies of 'forest users' have been developed through case study analysis. For example, Byron and Arnold (1999) compare those households for whom forest income is a choice, and those for whom it is a necessity of last resort; they distinguish between forest-dwelling peoples, such as hunter-gatherers, and those populations that are predominantly agricultural but who may also extract forest goods as is the case in Benue State. In Belcher, et.al,(2005), the authors conclude, based on a meta-analysis of 61 case studies of NTFP harvesting from around the world, that there are five main types of users: low-income subsistence producers, supplementary NTFP users, integrated NTFP collection with farming, specialized natural NTFP collectors, and specialized NTFP cultivators with high incomes from valuable specialty products (Belcher, et.al,2005). However, these typologies, while useful, have not yet been linked in the literature with analysis of how different types of forest users may come into conflict with conservation planning (such as in protected areas development), how the different typologies of forest users might be differentially impacted by loss of access to resources, and how these outcomes may influence future forest use and livelihood strategies (Adams and Hutton 2007). This paper aims to fill this gap in the literature of the study area and to achieve two goals: first, it seeks to determine how useful these typologies of NTFP users are, with a focus in particular on rural agricultural communities who use wild collected forest products to supplement farming income [these forest extractors are classified as 'supplementary strategy' producers in the Belcher, et.al, (2005) typology and 'sedentary agriculture at the forest frontier' in Sunderlin, et.al, (2005)]. These links between rural agricultural communities and forest use are explored through a case study of selected communities in Benue State. Secondly, the article tries to determine how effective law will be in the conservation enforcement in the use of protected forest to enhance sustainable development in the study area.
This study have shown that farmers often use a diverse variety of forest products; despite being farmers, they often may know a number of forest species and extract goods from a variety of categories, such as timber, fuelwood, fruits, medicines, etc. Nearly 90% of farmers surveyed for this research harvested some type of wild forest product, and the types of products harvested were diverse, as no one product dominated forest use patterns. This calls into question the methodology of some of the forest user typologies noted above that focus on only one or two kinds of NTFPs used by farmers. The paper provides an assessment that if forest environmental income is lost, such as by restricting access to protected areas, it may have significant livelihood impacts on the rural communities in the study area. While much of the literature on the links between forests and people has focused on impoverishment that can be caused by resettlement

and relocation from protected areas (Geisler 2003; Schmidt-Soltau 2003; Brockington and Igoe 2006; Brockington and others 2006), the evidence from Benue State rural agricultural communities suggests that even when people do not live in a protected area, they may lose access to income if borders are more rigorously enforced. This study highlights the fact that this problem is particularly acute for people identified as farmers; they may have forest income that is more 'invisible' to conservation managers, because these farmers do not live directly in protected areas and may not be seen as 'forest-dependent' people (i.e., they are not indigenous forest dwellers).

Additional attention needs to be paid to the differential costs of conservation for these different forest users; not all households in a community may be similarly affected. Detailed analysis of the subsistence and cash income needs of forest dependent households can help make estimates of the total costs of conservation explicit, including the opportunity costs to local communities (James, et.al, 2001). Those who are affected may have particular needs that should be met through livelihood interventions, if possible.

The paper indicates that the majority of rural communities in the study area (e.g. Ikwue Wildlife and Forest Reserve Igbo, Obadaga forest, Uchenyum-Ibilla, and Aliade Forest) visited who lived near a state-managed nature reserve were receiving cash incomes from forest-based activities. Many communities did not identify themselves as 'forest-dependent' households directly, yet analysis of their income streams revealed that a portion of the farming community had high levels of income dependency on forests (e.g. Oyinyi, Uchenyum-Ibilla, Aliade, Igbo, etc). Stricter enforcement of forest laws has meant that the collection of most forest produce is increasingly precarious for these families, and many households could face significant and negative welfare outcomes without access to this forest income due to a lack of equivalent substitutions. These dynamics need to be understood more clearly in order to balance the competing demands for conservation and for local livelihoods.

II. CONCEPTUAL CLARIFICATIONS

The concept of environment: The concept of environment has lent itself to diverse definitions or explanations as there are authors. This account for why to some the term 'environment' is inherently technical in scope and application (Oludayo, 2004). Generally, the term 'environment' grew up out of the old French term for 'around or circle'. In conventional usage today, it means surroundings or the total conditions surrounding an organism or group of organisms. In the western industrial tradition, the word 'environment' tends to mean that which surrounds man and awaits his dominance, exploitation, and control on behalf of the accumulation of wealth (Dantler, 1977). Tairu (1997), therefore, defined environment as 'the combination of natural objects (including living and non-living objects) made by human beings, the interrelationships between these and various circumstances, which surround people on earth." To this end, the environment is the whole complex of physical, social, cultural, economic and aesthetic factor which affect individuals and communities and ultimately determined their form, character, relationship and survival.

To Agboola (1988: 47), environment is a composite set of behavioural settings in which individuals within a community act with diverse consequences. In his words, "environment is conceived as an agglomeration of all the influence and conditions (whether internal or external) which affect the living conditions of an organism, in this instance, man." Environment has also been viewed as a complex relationship existing between the ecosystem and its inhabitants. Scientific explanation contends that environment is the product of a complex ecological system in which human beings and other living and non-living organism co-exist. In this context,

environment is characterized and classified into two broad categories, namely physical and cultural. The physical environment is the natural environment, which consists of biosphere, atmosphere, hydrosphere and lithosphere and their inherent resources. The cultural environment generally encompasses the way of life of a set of people in a specific location including human settlements, cultural, historical and religions aspects of human activities (Rall, 1980: 10). This definition is to some extent holistic in the sense that environment is perceived as the totality of nature and the natural resources, including the cultural heritage and the infrastructure essential for socio-economic activities (ICJ Reports, 1996, Para. 29).

Environment is perceived today in its totality by the recognition of the intrinsic relationship between man and natural environment and the quest to secure harmonious relationship with one another. This accounts for why statutory definitions of environment in most legal instruments are extensive and integrative in nature and incorporates the natural, human and non-living inhabitants of the earth. Thus, section 37 of the National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, No. 25 of 2007, provides that "Environment includes water, air, land and all plants and human beings or animals living therein and the interrelationship which exist among these or any of them." The Canadian Environmental Protection Act, 1998 in section 3(1), defines environment as the component of the earth and includes:

a. Air, land and water.
b. All layers of the atmosphere.
c. All organic and inorganic matter and living organisms, and
d. The interacting natural systems that include components referred to in paragraphs (a) to (c).

Similarly, Articles 174(1) and 175(2) of the European Community Treaty indicates that the scope of the environment extends to human beings, natural resources, land use, town and country planning, waste and water. This definition includes just about all areas of the environment, in particular, fauna and flora (which are part of natural resources) and climate. The inclusion of town and country planning underlies the fact that the environment includes man made as well as natural elements. This is in line with the definition of environment offered by the International Convention on Civil Liability for Environmental Damage, 1993 which includes in its definition of environment natural resources both biotic and abiotic, thus extending the scope of environment not only to natural environment but also to the man-made environment, including man-made landscapes, buildings and objects which form part of man's cultural heritage.

On an international level, it is worthy to note that approaches to defining the environment vary. Although the Stockholm Declaration (referred to as the foundation of modern international environmental law), does not include a definition of the environment, Principle II thereof refers to the natural resources of the earth as including "air, water, land, flora and fauna and natural ecosystems". Those treaties which have sought to provide some form of working definition of 'environment' have tended, like domestic regimes, to adopt definitions appropriate to their purpose. The Long Range Trans-boundary Air Pollution Convention, 1979, for example, has a definition of 'environment' that includes agriculture, forestry, materials, aquatic and other natural ecosystems and visibility (18. I. L. M. 1442 (1979).

From whatever perspective the environment is defined, it is our source of sustenance that we depend upon. We look to it for food, fuel, medicines and materials. We look to it also for a realm

of beauty and spiritual assistance. We can conclude therefore that environment is what the people within a particular society make of their habitat. It includes the natural resources of the earth- any material in its native state which when extracted has economic value. It includes not only timber, gas, oil, coal, minerals, lake and submerged lands, but also, features which supply all human needs and contribute to the health, welfare and benefit of a community, which are altogether essential to their well-being. This conclusion is apposite because environment is central to the survival of humanity. It is the totality of what constitutes the entire personality of man. Thus, it is said that everything about man, in connection to man, and for man, may be said to constitute the environment (Ogun, 2002). This can better be understood within the framework of the definition of environment by Black in his Black's Law Dictionary (1990: 534). According to him, environment is "the totality of physical, economic, cultural, aesthetic and social circumstances and factors which surround and affect the desirability and value of property and which attached the quality of people's lives; the surrounding conditions, influences or forces which influence or modify it." Thus, everything which affects and influences man, and which man affects, associates with or directs, and which man, in one way or the other has the propensity of accepting, influencing, relating to or interacting with, may be properly described as his environment. It is this environment that is subjected to one form of devastation or the other. It is also the myriads of these violations of environment that necessitates the evolution of environmental law to safeguard it.

Meaning of forest: A forest is a large tract of land covered with trees and underbush. It is a vegetation of land characterized largely by trees of different species. The Forestry law, Cap 44 Laws of Northern Nigeria, 1963, a law enacted for the preservation and control of forests, did not give any definition of what the word 'forest' means. By section 2 of the said law, 'forest' includes government forest reserves and protected forests, native authority forest reserves and protected forests, and communal forestry areas. The Oxford English dictionary defined Forestry as the science of planning and caring for large areas of trees. In other words, areas dominated by trees are areas regarded as forest vegetation. They include close canopy forest and open woodland where some leaves and twigs of adjacent trees overlap. The forest encompasses three vegetation types: the swamp forest, tropical rain forest and secondary regrowth. In Nigeria, all these are found in the southern part of the country. Some game reserves or protected ecosystems are created in some parts of the country especially in the northern savanna belts e.g. Yankari in Bauchi state and Borgu in Niger state to mention just a few. These game reserves are of woodland vegetation habouring and protecting some tree species. The swamp forest is found along the coastal and deltaic regions of Nigeria. It habours varieties of the same tree species. *Rhizophora,* which include *R. mangle, R. racemosa* and *R.harrisonii* others include tree species of *Avecennia gaminans nitida* (white mangrove) and shrub such as *Lagunculania racemosa* (white button wood) which are less abundant. Most important of them all is R. Racemosa which often reach a height of up to 45m and attain a girth of 2.7m. It is important to note that frequent cutting for fuelwood has prevented them from reaching maturity. Forests are important to mankind due to the benefits derivable from them (Egunjobi, 1993; Areola, 1991; Oriola, 2009; and Eboh 2005).

The Concept of Sustainable Development: The concept of "sustainable development" originated in a realization that the world's environment, its economies and the ways in which it treats its human and animal inhabitants, are all interlinked. One of the key documents dealing for the first time explicitly with development and its environmental limits was the 1980 World Conservation Strategy that aimed at achieving three main objectives: (a) to maintain essential

ecological processes and life-support systems (such as soil regeneration and protection, the recycling of nutrients, and the cleaning of waters) and which human survival and development depend; (b) to preserve genetic diversity (c) to ensure the sustainable utilization of species and ecosystems (notably fish and other wildlife, forests and grazing lands), which support millions of rural communities as well as major industries (IUCN, 1980). The succeeding document, The World Charter for Nature, 1983, took this notion further in its Principle 4 by stating that: 'ecosystems and organisms, as well as the land, marine, atmospheric resources that are utilized by man, shall be managed to achieve and maintain optimum sustainable productivity, but not in such a way as to endanger the integrity of those other ecosystems or species with which they coexist' (ILM 22 (1983), 457). Thus, by the time sustainable development was compellingly defined as "development that meets the needs of the present without compromising future generations to meet their own needs" in the report of the World Commission on Environment and Development (WCED), '*Our Common Future*' in 1987, it had already gained currency in international efforts to deal with environmental challenges (See UNGA Resolution 7).
It has been suggested by Sands (2003:35) that there are four elements to the concept:

(a) the need to preserve natural resources for the benefit of future generations (known as the principle of intergenerational equity);
(b) the aim of exploiting natural resources in a manner which is sustainable or prudent (i.e the principle of sustainable use);
(c) the equitable use of natural resources, implying that, in using resources, states must take account of the needs of other states (i.e the principle of equitable use or intergenerational equity);
(d) the need to ensure that environmental considerations are integrated into the economics of development needs are taken into account in applying environmental objectives (i.e the principle of integration).

The development of the concept is anchored on the recognition that protection of the environment cannot be considered in isolation from economic and development decisions. This is the cornerstone of the Brundtland Report which found that poverty was the mainstay of many environmental problems. This was more visible in the developing nations of the world. Not only were the developing nations promoting industrial growth on the scale of their more developed neighbours, which brought with it associated environmental problems, but measures to tackle poverty on the most basic level were causing environmental damage. For example, the destruction of vegetation to obtain food, or timber for fuel and building, left land unprotected so that its soil was washed away by rain. Without adequate soil, the land no longer retained water and became incapable of producing further food or timber, forcing the population to turn to new land and repeat the process of destruction. The consequence of this is that land degradation had caused millions of environmental refugees across national borders, especially in developing nations.

The international community first made a substantial effort to engage with the principle at the Earth Summit in Rio de Janeiro in 1992. An agenda of action was adopted which mapped out an ambitious and wide-ranging programme needed to move towards sustainability. A key element in that programme was that individual countries should establish their own sustainable development strategies. Accordingly, former UN Secretary-General Kofi Annan (2002) warned that 'unsustainable practices are woven deeply into the fabric of modern life … [t]he model of development we are accustomed to has been fruitful for a few, but flawed for the many. A path

to prosperity that ravages the environment and leaves a majority of humankind behind in squalor will soon prove to be a dead-end road for everyone.'

The concept of sustainable development demands an active *transition* on all levels of modern life. It requires innovative and integrated solutions that are based on the ultimate thresholds of the environment to provide essential natural functions. If all the challenges of modern society, which are separately addressed by various regimes, are to be met, some kind of *overarching objective* needs to be in place that sketches out a global and long-term picture of our world and helps to coordinate the fragmented attempts. This paper puts forward the argument that the unifying factor is encompassed in the notion of '*sustainability'*-a durable and equitable condition of humanity within the ultimate limits set by the functioning of essential natural systems that sustain life on Earth. As an ideal, sustainability has gained a status comparable to that of democracy, freedom and justice; it is universally desired, differently understood, complex in scope, extremely difficult to establish and impossible to do away with (Lafferty, 2004). No State would any longer claim not to be *pro* sustainability, but how to get there. There is no master plan for sustainability. In fact, humanity might forever strive for it. Like a state of justice, a state of sustainability may never be fully achieved, but this is by no means a reason for not trying.

While sustainability remains an ideal, sustainable development has been accepted by the international community as a guiding concept: 'the golden rule of our civilisation in the 21st century' (Decleris, 2000). In this sense, sustainable development has been described by New Zealand Parliamentary Commissioner for the Environment (2002), as the *means* to the *end* of sustainability or 'the 'journey toward the elusive goal of sustainability.' As an *idea* – an abstract creation of the human mind – sustainable development is based upon the shared values, morals and ethics of an increasingly interconnected and interdependent world (Cordonier, et al, 2005). The strength of sustainable development rests in the 'inescapable logical necessity' to seek *reconciliation and integration* between the many institutionally disconnected but intrinsically interlinked parts of global human society (See Hungary v. Slovakia; ICJ Reports 1996).

Some of the earlier approaches to sustainable development aimed at establishing norms for environmental protection and conservation that were ecology-oriented rather than utilization-oriented. They also expressed an understanding of the relevance of environmental protection for social-economic interests and needs of developing countries. However, the idea of sustainable development as expressed by the WCED had the most far-reaching implications for international law. In the report, sustainable development was explained as a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations (WCED, 1987: 46)

To further enhance the process of development and implementation of sustainable development in international law, the International Law Association(ILA) established the Committee on Legal Aspects of Sustainable Development, which completed its work in 2002 (See Report of the Seventieth Conference, New Delhi, 2002). The final result of this committee's work is the ILA New Delhi Declaration of Principles of International Law Relating to Sustainable Development (ILA Resolution 3/2002, annex as published as UN Doc. A/57/329, *New Delhi)*. In this Declaration, the ILA noted how sustainable development is now widely accepted as a global objective and that the concept has been aptly recognized in various international and national legal instruments. The ILA expressed the view that the objective of sustainable development involves a comprehensive and integrated approach to economic, social and political processes, which aims at the sustainable use of natural resources of the Earth and the protection of the

environment on which nature and human life as well as social and economic development depend and which seeks to realize the right of all human beings to an adequate living standard on the basis of their active, free and meaningful participation in development and in the fair distribution of benefits resulting there from, with due regard to the needs and interests of future generations (Ibid., 212).

When looking at the evolution of the concept of sustainable development it becomes apparent that the diversity and plurality of interests within the international community have shaped and expanded the scope of objectives and priorities that are bound together by the concept of sustainable development. There is (almost) no issue of international concern that has not or cannot be linked to sustainable development. Sustainable development thus provides the 'lens' through which the plurality of issues and interests can meaningfully be discussed. Finding a balance between the various elements, however, remains at the heart of the political debate over sustainable development. This balance is the key to establishing meaning and finding successful solutions to current problems of the world community. There is, apparently, urgency to this task, as expressed by the Council of the European Union:

> Unsustainable trends in relation to climate change and energy use, threats to public health, poverty and social exclusion, demographic pressure and ageing, management of natural resources, biodiversity loss, land use and transport still persist and new challenges are arising. Since these negative trends bring about a sense of urgency, short term action is required, whilst maintaining a longer term perspective. The main challenge is to gradually change our current unsustainable consumption and production patterns and the non integrated approach to policy-making (See the Council of the European Union, Brussels, 9 June 2006).

The conceptualization of sustainable development in the 2002 *Plan of Implementation* adopted in Johannesburg gives an indication of the conditions the international community has identified for sustainable development. As the Plan noted, Poverty eradication, changing unsustainable patterns of production and consumption, and protection and managing the natural resource base of economic and social development are overarching objectives of, and essential requirements for, sustainable development (2002 PoI, para. 2).

'Sustainable development' is arguably the most important general principle of environmental law. Indeed 'sustainable development' may be seen as the guiding principle which best illustrates the dynamic nature of rules, principles and the ethical values they represent. This is because in its broadest sense, the principle encompasses not merely the legal, but also the economic and political fields. The successful application of this principle would require not merely legal measures, but also economic and policy instruments in order to bring it about. Perhaps even more importantly, any human activity deemed useful, but which affects the environment in which we all live in a detrimental manner, may be required to fulfil the criterion of sustainability in the sense that such activity may not be allowed to reduce the capacity of the environment to ensure its continued usefulness for that and other human activities. This recognition of the broad nature and application of the principle of 'sustainable development', in terms of the various disciplines it covers, does raise questions concerning its progressive development as a general legal principle of environmental law. For example, at the international level, can it be said that it is specific enough in its formulation to be capable of creating legal obligations between States? One might want to argue that the function of general legal principles does not necessarily include

the formulation of legal rights and duties but is merely to guide the policies and actions of the authorities involved. Nevertheless, it may be important to know exactly how far individuals and other entities are legally required to implement the principle of sustainable development in their daily activities.

The principles of sustainable growth and sustainable development are seen by this paper to be the same. There is some doubt as to whether there is a distinction between these two principles, but any distinction appears more semantic than real, it being accepted that sustainable development implies a commitment to sustainable growth (Bell and McGillivray (2000) 16). Sustainable development according to Nigerian's Threatened Environment: A National profile:

> *.... is a notion, a movement, and an approach which has developed into a global wave of concerns, study, political mobilization and organization around the twin issues of environmental protection and economic development. The approach embodies the notion and ideal of a development process that is equitable and socially responsive, recognizing the extensive nature of power, deprivation and inequality between and within nations, classes and communities* (NEST, 1991).

Rural Communities: There is no one single universally acceptable definition of rural communities. This is because different professionals such as economists, sociologists, public administrators and geographers among others defined rural communities from the point of view of their disciplines. Thus, Oni and Bello (1987) viewed the concept of rural areas in terms of its characteristics. These include:

i. Relatively small size or low density of population spread over a large or small area.
ii. The main occupation of more than 70% of the population is farming at subsistence level.
iii. Non-availability of modern infrastructures such as motorable roads, pipe-borne water, electricity, health centres and educational institutions.
iv. Little or no influence of the population on government policies and programmes. The population is sometimes apathetic.
v. Low levels of per capital income and general poverty of the population.

In his own view, Williams (1988) sees the concept of rural areas as applying to "an area in which people depend mostly on primary industries for their living and in which most of the modern amenities are lacking." Although these definitions give a vivid picture or image of rural areas in Nigeria, scholars do not agree on a universal population data for rural areas because of divergence of boundaries and characteristics between and among rural communities. However, the most dominant and common features of Nigeria's rural communities are poverty, illiteracy, unemployment and inequality in the standards of living, and in some cases decay and stagnation in infrastructure development. These features are also dominant among the rural communities in the study area.

III. STUDY AREA, RESEARCH METHODOLOGY, SCOPE AND BACKGROUND TO STUDY

This study on the patterns and trends in the use of protected forests resources was conducted in selected rural areas of Benue State. Benue State derives its name from River Benue which is the second largest river in Nigeria. Benue State, located in the Middle Belt of Nigeria, approximately

320 kilometres south of Abuja, the capital of Nigeria, has its capital in Makurdi and was created in 1976 out of the defunct Benue – Plateau State. It currently has 23 Local Government Areas; three dominant ethnic groups are identified in the state, namely, the Tiv, Idoma and Igede. Being centrally located, it exhibits the biophysical and socio-cultural characteristics of both the Southern and Northern regions of Nigeria. Geographically, Benue State lies between longitudes $6^{o}45'$ and $8^{o}15'$E and latitude $7^{o}30'$ and $9^{o}45'$N. It has an estimated land area of about 32,511 km^2 with a population density of 86 persons/km^2 (Balogun: 1997).

In Benue State generally, most of the original natural forests has disappeared. The natural vegetation is now characterized by a mosaic of secondary forests and savanna with rolling hills which range between 150m to 300m above sea level, and the grassy open land induced by bush burning and clearing by farmers. The climate is typical tropical climate with two seasons – rainy season from April to October in the range of 150-180 mm, and the dry season from November to March. Temperatures fluctuate between 27 degrees centigrade to 37 degrees centigrade in the year. It is surrounded by five states, namely Nassarawa to the north, Taraba to the northeast, Cross River to the south, Anambra to the southwest and Kogi to the west. There is also a short international boundary between the state and the Republic of Cameroun along Nigeria's southeast border.

Benue State is a rich agricultural region, and is acclaimed to be the nation's "food basket" because of its rich and diverse agricultural produce which include yams, rice, beans, cassava, potatoes, maize, Soya beans, sorghum, beniseed, guinea corn, millet and coco-yam. It also boasts of one of the longest stretches of river systems in the country with potential for a viable fishing industry, dry season farming through irrigation and for an inland water way. Some of the rivers in the State include river Benue, the second largest in the country, river Katsina-Ala, rivers Oyongo, Oloko in Ameka-Owo, Ogwugwu and Ugbogo both in Ibilla, all in Oju L.G.A. The state is not only blessed with fertile land and an extensive riverine base that traverse its length and breadth, but it also contains substantial mineral deposits that have not been fully explored or exploited. These include Limestone, Gypsum, Anhydride, Kaolin, natural Gas, Salt, Petroleum Oil, Lead and Zinc, Barytes, Clay, Coal, Calcite, Germstones and Magnetite.

The local biotic communities in Nigeria can be grouped into two major zones, namely: forest zone and savanna zone. The forest zone is made up of vegetation having mainly trees and consists of mangrove swamp forests and tropical rain forests. The savanna zone is made up of mainly grasses and is further sub-divided into three savanna belts which are southern guinea savanna, Northern guinea savanna and Sahel savanna. Benue State falls within the Southern Guinea savanna zone. Southern Guinea savanna is the largest of all the biotic community in Nigeria with a moderate rainfall of between 150-180mm. It is characterized by tall trees with broad leaves scattered around the zone and deciduous in nature (i.e they shed their leaves during the dry season). The important trees in this zone include the locust bean trees, shea-butter and isobelina, etc.

Many of our problem stem from the way we have traditionally organized our institutions. The world's economy is totally interlocked with the earth's ecology, but our institutions are not. Environmental agencies must be given more capacity and more power to cope with the effects of unsustainable development polices. The most urgent task is therefore for Government (federal, state and local) to encourage development that is sustainable. Only in this way will the ecological

dimensions of policy be considered at the same time as the economic, trade, energy, agricultural and other dimensions on the same agenda and in the national and international interests.

Benue state is at the southern edge of the guinea savanna and the largest concentration of forests in Benue state can be found in Oju, Obi, Vandekiya, Ado, Konshisha and Gwer East Local Government Areas. Most of these areas are today in deeper ecological debt than financial debt that is ravaging most parts of the country. The regions' basic capital of environment and renewable resources is being used faster than it can restore or replace itself; its potential for development is being dangerously reduced perhaps most alarming, it is being reduced at levels of population and human activity that are much lower than the earth will have to support within the next 30 to 50 years. This downward spiral has to be interrupted and reversed.

The overriding concern of developing countries today, Nigeria inclusive, is to speed up their economic growth as rapidly as possible. In spite of increasing affluence and well-being in some parts of Nigeria, more of our people live in absolute destitution than ever before. Pervasive poverty, at a time when the mean and experience to eliminate it clearly exist, is the greatest failure of our society. This is also one of the greatest threats to the ecological basis of our collective future development, and by extension the development of the world. Growth is an essential precondition for overcoming poverty, but equally important is a much more equitable distribution of the proceeds of growth.

The scope of this paper is limited to the following forests and reserve areas.

(a) Ikwue wildlife and Forest Reserve Igbo, in Gwer East L.G.A.
(b) Obadaga forest, Uchenyum-Ibilla, Igede in Oju L.G.A.
(c) Ipinu-igede forest at Oyinyi Iyeche, Igede in Oju L.G.A.
(d) Ikwokwu-uwokwu forest of Oju L.G.A.
(e) Adum-East Forest in Obi L.G.A.
(f) Aliade Forest Reserve located along Otukpo Road in Gwer East L.G.A.
(g) Anyuwogbu-Ibilla Forest in Oju L.G.A.

Apart from the Ikwue wild life and forest reserve at Igbo and the Aliade forest reserve which are Government protected forests and reserve forests, all the other forests mentioned above are communal forestry areas and by virtue of the provisions of section 36 of the Forestry Law, 1963, they are managed and controlled by the native community themselves. The problem with the management and control of these communal forestry areas is that the community lacks the capacity to actually control the forests. This is in respect of personnel and instrument of sanctions or punishment which are lacking or largely rudimentary.

The Forestry Law that is in operation in Benue State is the Forestry Law, Cap. 44, Laws of Northern Nigeria, 1963. It was established as a law for the preservation and control of forests. This Law is an updated version of the forestry ordinance No. 95 of 1923. Under section 4 of the Law, it shall be lawful for the Governor to constitute as Government forest reserves any lands at the disposal of Government or native lands and any lands in respect of which it appears to the Governor on the advice of the Chief Conservator of Forests that the forest growth on such lands should be protected or reserved or forest growth be established. The Governor may by notice in the Gazette declare any lands to be a Government protected forest. The implication of declaring a land as Government forest reserve or protected forest is that any right of way or watercourse in

respect of that land shall be closed (see section 15). In addition, no right shall be acquired in or over the land; no new house shall be built; no tree shall be cut; and no forest produce shall be removed (section 19) except with the permission in writing of the district officer or a forestry officer of a rank not below that of Assistant Conservator of forests. By section 27 of the Law every right in or over land within an area constituting a Native Authority forest reserve, shall be extinguished upon the coming into operation of the order.

The Native Authority (now Local Government Council) may make rules for the protection and management of communal forestry areas within the area of its jurisdiction for all or any of the following purposes:

(a) Prescribing the duties of native communities;
(b) Prohibiting or regulating the taking, free or on payment, of forest produce or of any specified kind of forest produce.
(c) Prohibiting the sale of forest produce or of any specified kind of forest produce by any person other than specified persons or classes of persons;
(d) Prohibiting the destruction of, or any act which may tend to the destruction of or cause injury to, any forest produce or forest growth or forest property;
(e) Providing for the seizure, detention, and disposal of timber or forest produce taken, collected, prepared, sold, purchased, possessed or not marked, in contravention of the rules or in respect of which any offence against the rules has been committed;
(f) Providing for the establishment of nurseries and for the afforestation of lands, the preservation and production of forest produce and the introduction of new species of trees or other forest produce;
(g) Providing for the management utilization and protection of the areas;
(h) Protecting the forest produce in the areas by;
(i) Prescribing the time at which and the manner in which the rights recognized by native law and custom may be exercised;
(j) Prohibiting the taking or destruction of any specified kind of timber or minor forest produce in the exercise of such rights; and
(k) Prohibiting the exercise of all or any of such rights in any specified part of the area;
(l) Generally for giving effect to the objects and purposes for which the areas are established.

Native Community means any group of persons occupying any lands in accordance with and subject to native law.

According to the Forestry Law, 1963, protected forests and reserves are to have no exploitative activities within them, nor in most cases any households resident there, and into this category fall the Ikwue Wildlife and Forest Reserve Igbo and Aliade Forest located along Otukpo Road all in Gwer East L.G.A. The primary uses of the forests in the study areas were for the extraction of forest products like timber and non-timber forest products (NTFPs) through day trips into the forests and reserves by people in surrounding communities. There are Forest Guards/Rangers who patrolled the forests boundaries occasionally to prevent entry into the forests by the people of the communities. It used to be relatively easy for most people to extract forest products with little fear of getting caught by the Forest Guards/Rangers if they engaged in such venture in the dark when the law enforcement officers might have gone.

The methodology used in this research is purely doctrinal – an analysis of statutes, articles, text-books, and other resources. Although, no formal empirical investigation was carried out, some individuals in key offices were interviewed to complement what is on the papers. Also, some households were interviewed to know the estimate in both quantity and income of their total forest products extraction, along with questions about the seasons and labour needed. This was necessary to get a comprehensive picture of the effects of forest products on the livelihoods of the people. This quantitative study was supplemented by oral interviews which were also held with the people of the various communities or forest product collectors to learn more about techniques for harvesting, land use types for various forest products, changes in harvesting over time, and restrictions on harvesting as a result of Forestry law enforcement. A market survey was conducted at the Onyike-market, Ibilla, Ihiokwu-Ito market, and Aliade main-market to assess prices of NTFPs. Head of Forest Guards in Oju L.G.A., Elder Moses Onda was also interviewed. Additionally, during the research period several trips were made into the forests in the study area to look at forest product collection in situ. Harvesters were accompanied into the forest as they sought out forest products to understand the physical processes involved in forest harvesting, how products were selected for harvest, and where and how harvesters might encounter Forestry law enforcement personnel.

IV. FOREST USE AMONG THE BENUE RURAL AGRICULTURAL COMMUNITIES

Forest produce obtainable from forests largely depends on the location of the forest in question. However, by section 2 of the Forestry Law, 1963, 'forest produce' includes: - (a) timber, firewood, charcoal, rubber, gutta percha, latex, wood oil, gum, resin, natural varnish, tanning extracts, tanning barks, fruits, fibres, bark and Lac, whether found in or brought from a forest or not; and (b)(i) trees and all other parts or produce of trees not otherwise herein mentioned; (ii) plants, including chambers and grasses, creepers and all parts or produce of such plants; (iii) wood cashes; (iv) peat surface soil and minerals other than minerals within the meaning of any enactment regulating the working of minerals; (v) gravel, limestone, rock and laterite; (vi) honey, bees wax, guano, silk-cocoons, humus and all produce from animals, when found in or brought from a forest.

Overall, forests played an important livelihood role for many families in Benue State, as 65% households harvested some sort of wild plant products from the forests. Households on average collected different categories of forest goods or wild species (timber, charcoal, fuelwood, fruits, leaves, resins/aromatics, medicinals, edible plants, and animal products). The characteristics of collection and conservation impact of these activities are outlined by category below.

Timber: By section 2 of the forestry law under reference, Timber includes all trees, whether standing, fallen or felled, stumps of trees and all wood, whether or not cut up or fashioned or hollowed out for any purpose. To take timber means to fell, lop or girdle trees or to carry away any timber from the lands which the trees have fallen or been felled, whether the trees have been felled by cutting or by removing the soil from the roots or by any other method or combination of methods. About a half of households in the study areas cut timber for sale from the forests. Others were forced to rely on freely collected wood in the forests or village lands, or else purchased wood, either legally or on the black market from illegal loggers. Timber is not a lucrative business for local households because local households had no means to transport large numbers of logs out of the forests/reserve (e.g. they lacked resources to owned or had access to truck), and all local logging was done by handsaws, in contrast to timber contractors in which

case even small scale logging is done with chainsaws. However, despite the low amount of timber harvested per household, the conservation impact of logging is high, as whole stems of valuable hardwoods were the main targets. However, logging was reported by informants to be declining in importance of recent, as timber was the primary forest product that government through the forest rangers had begun to crack down on. Households could be fined between 50-100 Naira (less than one US dollar) and lose any timber they had cut if discovered. They may also be liable to six months imprisonment (see sections 19 and 50 of the forestry law, 1963).

Charcoal: Charcoal-making is a lucrative forest-based income activity in the study areas, one that about 58% of households (men and women) participate in. Charcoal is made when a freshly cut wood is heated/burned in an enclosed furnace fire prepared for that purpose. Survey results revealed that individual households made on average 20 to 30 bags of charcoal a month, and if multiplied by the average number of charcoal making households surrounding the forests in the study area, approximately 1,000 bags of charcoal were being produced per month from the forests/reserves. Households either transports their charcoal themselves to the markets, usually in urban centres of Makurdi, Otukpo, Gboko, etc or sold them to traders who came to villages. These traders sold the charcoal at open markets in urban centres to low and middle income earners who cannot afford to buy kerosene at the exorbitant price of between 150 to 250 Niara (about US$1.5) per litre.

Charcoal was the only forest product for which there was no subsistence demand. The conservation impact of charcoal making is high, because of the large numbers of species used, the use of stems, and the relatively low efficiency of charcoal making. There were few conservation measures taken to limit the species used or type of forests exploited by charcoal makers, with the exception of species that were small in diameter but made heavy charcoal; species that fired badly and left unburnt heartwood; or species that fired too well and produced only crumbly small diameter charcoal.

Charcoal makers relied on the sporadic monitoring of the forests to enable them to use the forests there freely; no household reported making charcoal from trees on their private lands or gardens. Although the government is aware that charcoal is made from trees, there is no punishment for making charcoal which is as severe as that for timber cutting or harvesting.

Fuelwood: Fuelwood is the primary forest product in Benue rural communities for which there is both a high subsistence and a high commercial demand. Nearly 99% of rural households in the study area used fuelwood as their main energy source (less than one percent of households had electricity or kerosene for cooking). In fact fuelwood trading has become a lucrative occupation for both men and women in the study areas. Before the booming era of fuelwood trading, fuelwood harvesting was technically illegal in the forests; in fact removal of dry wood and branches was openly tolerated by forests managers/rangers. The conservation impact of fuelwood use then was moderate. Selling fuelwood was seen as one of the only occupations for women in this area, requiring neither capital outlay nor any special equipment. Today the story has changed. Both men and women have joined the occupation and nearly 80% of the total fuelwood in the study area came from trees in the forests. The devastitating effects or the conservation impact of fuelwood use today is a source of worry to all and needs to be checked.

Forest Fruits: Wild fruits were collected from a variety of species in both open and closed forest in the rural communities. In some cases children were the primary collectors of forests fruits such as wild mango, amampia, okpuruhu, etc. Men are involved in the collection of honey, bees wax, guano, silk-cocoons, etc. The conservation impact of this activity is low to moderate although, some households that harvested fruits use to cut down fruit trees to get the fruit if it

was too high up, particularly fruits like wild mango. Some of the forests fruits collected are sold to generate income no matter how small.

Leaves/Edible Plants: In addition to fuelwood, leaves were collected for making thatching, for making brooms, for wrapping foods, and for making craft items. Women and children dominated the collection of all these leaves, as they were light and easy to carry, required no special equipment or specialized knowledge, and were generally found in forests closer to villages. The conservation impact of leaf harvesting is likely to be low as leaf reproduction replaces those harvested. Edible plants were a small category of subsistence forest products. Most families in the study area collect foods for themselves or for their livestock from forests. Additionally, a majority of households let their large animals graze freely for fodder in the forests/reserve lands, although it was not possible to accurately estimate the amount of fodder consumed. Grazing may likely have a moderate to high conservation impact, as animals left to graze can alter forest composition and hinder new growth, but grazing did not take place year round and was confined to areas of the forests close to villages, as households did not want to risk losing animals if they were left to graze farther into the wild forests.

Medicinal Plants: Fewer members of the communities engage in the collection of medicinal plants compare to other forests products. The low patronage of medicinal plants was attributed not only to the small number of economically valuable species and a lack of knowledge among collectors about where medicinal plants could be found but the fact that only specialized persons have knowledge of medicinal plants. The conservation impact is likely to be moderate for medicinal plant harvesting; some medicines were made from leaves and bark that could be harvested sustainably, while for some medicines the whole plant or roots were needed.

Forest Animals: Benue State is known for high levels of poaching for wild animals and almost every member of the community engage in one form of hunting for the popular bush meat or the other. The few local people who continued to hunt usually did so only in conjunction with another activity, such as cutting timber, as there was rarely enough wildlife available to make hunting worthwhile on its own all year round. The conservation impact of forests animals hunting is likely to be high because the hunters do engage in bush burning to facilitate gaming, especially during the dry season. Moreover, most animal species are going into extinction.

V. PATTERNS AND TRENDS IN THE USE OF NATURAL RESOURCES BY BENUE RURAL COMMUNITIES

In discussing the patterns and trends in the use of natural resources in the study area, the following inter-related questions need to be asked: what policies and practices will lead to sustainable resource use and how can we encourage attitudes of stewardship on the part of resource users and managers so that they will look beyond their own use and practices to the needs of other people, both those living now and those of future generations? The answer to these questions forms the basis discussions in this section.

The first pattern is consumptive use of resources. People in rural areas make use of natural lands that are in close proximity to them. Where people harvest natural resources in order to provide for their needs for food, shelter, tools, fuel and clothing, the practice is referred to as consumptive use of resources. This kind of exploitation does not appear in the calculations of the market economy of a country. Although, people may barter or sell such goods in exchange for other goods or services in their local markets, most consumptive use involves family members engaged in hunting and gathering to meet their own needs. In other words, people are hunting for

game, fishing or gathering fruits and nuts in order to meet their food needs, or they are gathering natural products like firewood, forage for animals or wood and palm leaves for constructing shelters, or natural products for traditional medicines. For example, wild game, or "bush meat", is harvested in many parts of Nigeria, especially Benue State in North Central Geo-political zone. This wild game provides a large proportion of the protein needs of the people. Without access to these resources, people's living standard would decline and their very existence could be threatened. This kind of dependence is a common feature in most rural communities in Nigeria and their lives would be seriously affected if they were denied access to these "free" resources without any alternative.

Secondly, there is productive use of resources. This refers to the exploitation of ecosystems resources for national or international markets. This is an enormously important source of revenue and employment for people in Nigeria. Another productive use is the collection of wild species of plants and animals for cultivation or domestication. The wild species may provide the initial breeding stock for commercial plantations or they may be used as sources of genes to be introduced into existing crop plants or animals to improve their resistance or to add other desirable genetic traits. And wild species continue to provide sources of new medicines.
There is need to emphasize that the consumptive and productive use of natural ecosystem products is strongly influenced by the political and legal institutions of the country. For example, private ownership clearly restricts access to natural areas, where as community ownership is permissive of use by members of the community. State ownership of natural resources implies regulated use; here, public policy is the key to access these resources. In all these arrangements- private, communal or state- there is the potential for sustainable use of the resources, or for unsustainable use leading to the loss of the resources as well as the services provided by the natural ecosystem being exploited. Therefore, the perspective of stewardship is vital. Do the resource managers and harvesters see themselves as caretakers, as well as exploiters of the natural resource? Are public policies that encourage stewardship and sustainability in place? Answers to these questions are in the negative as it relates to the study area in use of natural resources.

Another pattern and trend in the use of natural resources is exhibited in the concept of tragedy of the commons. Where a resource is owned by many people in common or by no one, it is known as a common pool resource, or a commons. Examples of natural resources commons are many: grasslands where private cattle rearers or herders graze their livestock, coastal and open-ocean fisheries used by commercial fishers; groundwater drawn for private estates and farms; naturally owned forestlands and products harvested for fuel, and the atmosphere, which is polluted by private industry and traffic, etc.
The exploitation of such common pool resources presents some serious problems and can lead to the eventual ruin of the resource- a phenomenon called the tragedy of the commons; after biologist Garrett Hardin's classic essay in 1968 by that title. Sustainability requires that common pool resources be maintained for the benefit of future users, not just present ones.

As described by Hardin, the original "common" were areas of pasture land in England provided free by the king to anyone who wished to graze cattle. In the parable, herders were quick to realize that whoever grazed the most cattle stood to benefit the most. Even if they realized that particular commons was being overgrazed, those who withdrew their cattle simply sacrificed personal profits, while others went on using that commons. One herder's loss became another's

gain, and the commons was overgrazed in any case. Consequently, herders would add to their herds until the commons was totally destroyed. They were locked into a system that led to their ruin.

Hardin's parable applies to a limited but significant set of problems in which there is open access to the commons, but there is no regulating authority (or there is one, but it is ineffective) and no functioning community. Exploitation of the commons then becomes a free-for-all in which profit is the only motive. Persistent cutting of trees from our forests have consistently demonstrated this problem.

One arrangement that can mitigate the tragedy is private ownership. When a renewable natural resource is privately owned, access to it is restricted, and, in theory, it will be exploited in a manner that guarantees a continuing harvest for its owner(s). This theory does not hold, however, when an owner maximizes immediate income and then move on. Most owners, though, will be in for the long run and manage the resources more responsively.

Where private ownership is unworkable, the alternative is to regulate access to the commons. Regulation should allow for protection so that the benefits derived from the commons can be sustained. Such regulation can reside in the state, but it does not have to. In fact, the most sustainable approach to maintaining the commons may be local community control, wherein the power to manage the common resides in those who directly benefit most from their use and there are strong social ties and customs that can function well overtime in protecting the commons. By contrast, in many situations, state control of a common has accelerated its ruin and led to an associated social breakdown and impoverishment of people.

VI. CHALLENGES AND LEGAL IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT

One of the challenges for forest resources protection in the study area is that forest income contributed on average more than 50% of cash income for the people in the study area showing how important forests are to overall household livelihoods. This high dependency accounted for some, though not all, of the communities with the greatest conservation impact. For example, of the communities' high dependency rate, Ikwe wild life and forest reserve community is known for charcoal making and others for timber harvesting. While this accounts for 58% of charcoal-producing households, it is only 35% of the timbering households, indicating high dependency households are not necessarily the best or only targets for conservation enforcement.

But close analysis suggests that the high dependency households were in fact different from the households with no to low dependency on the forest. This is because the highly dependent households used their forest income to smooth gaps in income from other sectors. These dependent households tended to be doing worse in terms of on and off-farm income; they had significantly lower levels of both total agricultural income as well as relative agricultural income (the percentage of total household income from agriculture), as well as total livestock income.

Secondly, a lack of access to off-farm employment income was also very significantly correlated to forest dependency, as those with no dependency on forests had on average more than 50 times the income from wage labor as high dependency households. Those households with sources of wage or business income had on average only 37, 500 Naira ($250 US) in income from forest produce, while those households with no alterative employment had income from forests averaging 67, 500 Naira ($450 US).

Additionally, forests were not only important in terms of supplementing overall income to households, they were also important in terms of when that income was supplied, a finding noted elsewhere (Pattanayak and Sills 2001; de Merode and others 2004). In Uchenyum-Ibilla, Oyinyi, etc, households had excess labor in May and September before the late rice was planted, in December and January before harvest, and in mid-rainy season between the two rice seasons. Thus these were the times when most households were free to collect forest products. Forest products were usually not collected by households that had labor constraints during the agricultural season, implying that agricultural production may serve as a natural check on forest product collection for farmers if proper incentives are provided to the people.

It is important to note the distinction between use of NTFPs for overall income diversification (such as to supplement income during seasons of low agricultural labour demand) and for coping in case of loss of crops or other emergencies; these two strategies can be classified as ex-ante and ex-post respectively (Pattanayak and Sills 2001; Delacote 2007). The research revealed that forest income in the study area is important in both ways. For farmers with mid to higher levels of income from agriculture, forest goods could be used to smooth consumption in off-seasons and formed an important ex-ante livelihood strategy. For the poorest households, they often had labor constraints that prohibited their making use of forests on a regular basis, but rather, the poor used them in ex-post ways as a type of insurance for emergencies or unexpected problems. Poorer households would often go collect products at times of the year when they needed extra cash (such as before the lunar New Year's holidays and the beginning of the school year for children's school fees), and additionally could call upon forest reserves if the household had an unexpected emergency, such as a family illness, for which a quick infusion of cash was needed. Few households reported significant cash savings from year to year; household expenses actually exceeded calculated yearly cash income, indicating forests remained an important source to call upon for cash.

A further challenge is that a number of households would be affected if the borders of the forests were enforced according to the law and all forest access restricted, although such impacts would not be evenly spread among all households. Fifty-five percent of households had used some forest product in the previous year, but not all these households used products regularly or sold them for cash or had high dependence on these products. Those households who exploited forest resources for cash income (estimated to be 55%) would have an income decrease if enforcement was tightened. These figures include only cash income however; households that sourced subsistence goods, primarily fuelwood, for example, would have to expend money or labor or both on substitutes, should access be completely restricted through blanket enforcement bans. Most families used on average more than 4,000 kg of fuelwood a year, which would have cost 35,000 Naira ($150 US) to buy at the market. Considering that the average household cash income is estimated at only 6,000 Naira ($4.00 US) a year, many families would face economic hardship if they had to divert 40% of their income to the purchase of fuelwood. Other important subsistence goods included Bamboo for house construction and wild medicinal plants, both of which would have to be purchased should natural resources in the study area be restricted. The results indicate strong links between forest use and farmer livelihoods around the protected forests and nature reserve of the study area. A majority of households surveyed received some form of cash income from forest based sources, and a large majority of households also relied on forests for subsistence goods, namely fuelwood. A core subset of the community had strong dependency on the forest products for much of their income, and those households that had no

other options to access cash income (such as low levels of livestock or no access to wage labour) were more dependent on this forest use.

Due to the changing nature of global climate, arising from human activities, the government at all levels are increasingly trying to stop all exploitation activities rather than letting it go as they had in the past. Because according to law there is to be no collection of forest products at all—no matter the relative conservation impact—in any special use forest, it is likely that there will be increasing pressure on households living near protected areas in the study areas in the future, both in the form of relocation as well as in restricted access. This may have serious livelihood impacts which have been overlooked, and which this paper has sought to emphasize. Few of the government's protected areas have sufficient attention to or funding for livelihood impacts from conservation and make no reference to how households are to economically cope with restrictions on resources (McElwee 2002, 2004). Most of the funding for conservation from the government is for direct conservation management (such as salaries of rangers, mapping of park resources, etc) and not for development activities for affected populations. This problem is likely to be particularly acute for farmers living around protected areas, especially many peasant households that may be assumed to have little or no benefit from forestry, and thus under-represent it. Therefore these farmers may lose access to and use of forests as conservation laws are made stronger and imposed in new areas, simply because these farmers' forest use has been 'invisible'. Even donors and NGOs in the study area focused on poverty and environment are also often unaware of the possible contributions of protected forests to farming households because so few assessment exercises have been carried out that have tried to quantify this forest income.

Another challenge is the aspect of farmers' forest use that has been ignored in the past which is the strong diversity in number of species used. While the total number of species documented to be used by farmers in the study area is lower than the total number of species collected by indigenous forest-dwellers in other areas of the world (Luoga, et.al, 2000), it is higher than the number of NTFPs collected by agricultural colonists documented for the Amazon, for example (Summers, et.al, 2004). This may indicate the need to distinguish in forest use typologies, such as those of Ruiz Perez, et.al (2004) and Sunderlin, et.al (2005) an intermediate category of farmers who have relatively high levels of income from a diverse group of NTFP products. In fact, many studies on forest use among farmers tend to focus on one or two products only that was cultivated by farmers in gardens, and ignored all other forms of wild-harvested NTFPs by households (see for example the meta-analysis of forest use done by researchers with CIFOR that forms the basis for the articles by Ruiz Pe´rez, et.al, 2004 and Belcher, et.al, 2005). Thus, those studies may not in fact well-representative of NTFP use in Benue rural agricultural communities because it did not assess the relative importance of all NTFPs, both wild and cultivated, that were important to local farmers, as this study has attempted to do.

There is also the challenge of the fact that farmers' resource use is the strongly seasonal nature of their exploitation and the role of forests as safety-nets when agriculture was unproductive or labour supply in excess. As Byron and Arnold (1999) states ''The information available suggests that for most users, the importance of forest products income is usually more in the way it fills gaps and complements other income, than in its absolute magnitude or share of overall household income.'' (p. 792) While some studies assume a competitive labour allocation between agriculture and forest activities (Gopalakrishnan, et.al, 2005), in reality, the two are often complementary; farmers often undertake forest activities in agricultural slack seasons. The forests of the study areas served as a 'bank' for households that they could draw on in times of

particular need as well. This mirrors findings from elsewhere that highlights the important 'safety net' roles forests often play (See for example McSweeney 2004; Shackleton and Shackleton 2004).

There are numerous impacts from conservation enforcement that have been documented elsewhere in the world that should serve a potential source of warning to government of Benue State as it strengthens management at protected areas (Geisler 1994; Chatty and Colchester 2002). Although much literature has focused on the poverty implications of eviction and physical relocation away from protected areas (Brockington and Igoe 2006; Schmidt-Soltau and Brockington 2007), even in places where forest users are not evicted, there are likely to be welfare impacts from conservation enforcement (Adams, et.al, 2004; Brockington and Schmidt-Soltau 2004). The competing valuation of resources from local areas to global scales compounds the problem; while the benefits of strict conservation often accrue regionally or globally, the costs are usually borne most locally in terms of loss of access to livelihoods and incomes (Wells 1992). Furthermore, it is often the most vulnerable or dependent households in communities that bear the brunt of such conservation costs, which are not spread equally (Colchester 2006). Yet there are only a few studies that concretely address the degree to which conservation enforcement will have welfare impacts, who will be most affected, and how these impacts might be avoided (Ghimire and Pimbert 1997).

There is a lack of sufficient studies on the overall costs of conservation for local peoples, and how this might be compensated or diminished; as Ferraro (2002) notes, 'There is a dearth of quantitative data on the costs borne by local residents when protected areas are established in low-income nations' (p.262). For example, many estimates of how much it costs to fund a global protected areas system include management costs only, and not the opportunity costs to local communities, which remain unvalued, and unfunded as a consequence. These opportunity costs are defined by Wells (1992) as 'the benefits foregone as a result of lost access to the natural resources of protected areas. There are generally two types of opportunity cost. First the consumptive benefits foregone from potential harvests of natural products…Second, and potentially of much greater value, are the economic benefits that could have been gained from conversion of the protected areas to an alternative use—such as agriculture, mining of hydro-electric power generation' (pp. 241–242). James and others (2001) estimated that the opportunity costs of global protected areas may be as high as $5 billion a year, which is significantly more than $750 million spent on actual management costs (Balmford and Whitten 2003). Thus, the opportunity costs to local communities include both direct losses of income as well as more indirect costs such as loss of agricultural crops to wildlife predation from protected species in nearby parks. Yet there are only a handful of studies that have tried to quantify these costs in specific protected areas (Mishra 1997). This research shows the need for more detailed accounting of opportunity costs due to protected areas. Particularly in circumstances where management plans call for the curtailment of freely collected resources, it is important to be able to know who will be most affected, so these impacts might be ameliorated. The evidence collected indicates that on the basis of income alone, loss of access to the forests will adversely affect the majority of the thousands of farming households living around the protected forests and reserve in some way, although the costs are not equally distributed. The largest costs will be borne by the 15% of households who derived more than half their income from the forests; these were households who could be distinguished by their lower wage labor, livestock and agricultural income.

Targeting of Conservation Interventions Better income accounting of the conservation costs of protected areas could be used to help design appropriate approaches to conservation that will not increase poverty (Fisher and others 2005); examples of where this information could be useful include the new payments for environmental services approaches that are becoming increasingly popular in other developing world. In order for such payments to work efficiently and effectively, they need to be targeted to 'compensate agents who would have benefited from the biodiversity threatening activity', not necessarily to everyone in a community (Wunder 2007). For example, one possible way to avoid the negative outcomes of a complete enforcement ban on extraction from the forests is to target those households that harvested certain high conservation value products (such as wild animals or timber) or who were having a disproportionate environmental impact through high levels of resource draw (such as charcoal makers). Studies elsewhere have shown that rather than blanket conservation enforcement, it often makes sense to look at highly targeted interventions (Coomes, et.al, 2004). Among the Benue rural communities, less than half of those who made charcoal were having a disproportionate conservation impact in that they used large quantities of standing wood. On the other hand, the majority of households collected fuelwood, which was less detrimental to forest structure as mostly leaves and dead wood and branches were collected, not whole trees. A total forest enforcement policy would exclude both groups of users, while in fact it is the charcoal makers that were likely having the largest impact. Enforcing a charcoal ban, while allowing the legal collection of dry wood from dead branches, would be one way to better target enforcement in Benue state.

Targeting can be applied not just to certain species or products of high conservation impact, but also to groups of households that have higher levels of forest dependency. In the study area, the most forest dependent households were not significantly different from others in terms of overall income. The more forest dependent households could be best identified not by overall income class, but by analysis of their access to alternative income streams. Those without access to wage labour or government salaries tended to be more dependent, as did those with less income from livestock and agriculture. These households might be successfully targeted to reduce their conservation impact.

A final aspect of targeting that would incorporate the needs of local livelihoods of farmers would be seasonally based conservation interventions. As noted earlier, the nature of forest use is strongly seasonal in the study area, primarily occurring during the agricultural slack seasons of after harvesting and before planting season, with pre-planting season being the most financially important as it was a time to raise cash for the Christmas and New Year's celebrations. It is also likely that this season might be an appropriate time to allow more harvesting, given most plant growth cycles and reproduction (i.e., presence of dead branches and dried wood in dry season and harmattan periods). Paying attention to when households use forest products could be used in conjunction with conservation measures such as limited seasons for NTFP collecting to ensure reproduction of key species, as long as livelihood needs throughout the year could be matched satisfactorily with growing seasons for forest produce or reproduction seasons for animals.

One possible remedy to loss of income if the borders of the forests are to be more strictly enforced is the substitution of other income sources for that lost. A common strategy in conservation has been to try to couple the protection of lands through enforcement with development strategies to reduce household dependence on protected areas, often called Integrated Conservation and Development Projects or ICDPs (Adams and Hulme 2001). Too often, however, ICDPs have been designed with only loose linkages between the households whose forest activities were curtailed and the provision of alternative income sources (Coad, et.al

2008). Often, compensation for lost lands or livelihoods has been far less than the value of decreased income opportunities (Schmidt-Soltau 2004) or has involved new activities that might favor some groups over others, leading to income inequality. In other cases, the income substitution activities turn out to be inappropriate for the local situation, and people revert back to protected areas use (Peters 1998). An example is the use by some ICDPs of investment in agriculture as a substitute for forest income, particularly where farmers are the forest users, as is the case in this study area. Some ICDPs have emphasized that increasing productivity through intensification of agriculture and higher prices for crops will lead to less pressure for land expansion into forests (Green, et.al, 2005).

However, there is also evidence that increased income in the form of higher prices for agricultural crops is a major factor behind deforestation as farms expand in response to the market (Angelsen 1999). In Benue State, the fact that more forest dependent households had less land available is likely to affect their ability to benefit from agricultural interventions. This is confirmed by work in India, where certain types of non-farm income were shown to even out income inequality in communities in ways that agriculture investment did not, as agriculture is linked to land access and quality which is often unevenly distributed (Mahapatra, et.al, 2005).

In Benue State, another issue presented itself as a barrier to substituting agriculture for forest use; that is the fact that agriculture produced less net income than wage labour because of the higher capital expenses involved for buying pesticides, fertilizers, irrigation fees, hired labour, milling, etc. For forest goods, there are no capital expenses, as all were freely collected with no special equipment or processing needed, and no need for cash inputs as they were wild harvested, not cultivated. Finding a substitution for forest income that would be effective would require an alternative that had little initial capital outlay, as was the case with forest extraction. Thus, wage labor appears to be a better alternative than agriculture for many forest-dependent households, as wage labor usually requires no initial access to capital. Similar findings have been reported for India by Reddy and Chakravarty (1999). Access to wage labour appeared to reduce dependency on forests among residents, as households near the protected forests that had non-forest related employment (doing wage labour, receiving government salaries or pensions, or service or business income) had significantly lower forest exploitation incomes than those who did not have wage income. Increasing these waged opportunities might be one of the more effective conservation investments in the Benue rural communities, particularly if these jobs were to be targeted at the high conservation impact households (i.e., charcoal makers, hunters and timber traders, burnt-bricks making, etc).

There is also the challenge of deforestation through the use of forest resources for baking burnt bricks (Blocks) in Benue State. This challenge is prominent in Makurdi, Gwer East, Gwer West, Gboko, Konshisha, Ukum, K/Ala, etc. The practice is such that blocks are molded into predetermined sizes and arranged in a furnace made of big and medium size wood extracted from the nearby forests. More woods will be added until the blocks are baked into brown colour signifying that they are strong enough to be used for making houses. The conservation impact is likely to be high due to the magnitude of trees that are being removed for this purpose.

The purpose of a legal framework as an integral part of a National Environmental Policy is to consolidate, strengthen, provide and extend legislation for environmental protection and improvement in all spheres whilst also providing for effective implementation and enforcement procedures. Therefore, actions were taken to:

(a) Promulgate a series of appropriate environmental protection laws;

(b) Harmonise the various existing environmental protection legislations;
(c) Make it a constitutional duty of government – Federal, States and Local – to safeguard the environment and aspire to have a safe and healthy nation;
(d) Encourage and institute incentive measures for installation and provision of anti-pollution equipment and devices;
(e) Stipulate procedures and regulations for implementing the national environmental policy.

Legal options may therefore be regarded as alternative policy options for environmental protection, especially where other options are rendered nugatory or unimportant. Legal option could be in the form of enactment or regulatory measures, nuisance remedy, enforcement of citizen's right to pleasant environment, and public trust.

The regulation-end-enforcement option involves the setting of minimum standard and enforcing them through a system of sanctions. The regulations might be imposed in a variety of ways, through issuing licenses, permits or certificate of registration for felling timbers, by order of legislative, regulatory agencies or courts. The enforcement measure could be fines or closure of the timber factory, etc.

The right of every citizen to live in clean, healthy, and pleasant environment must be a requirement of law. Thus, for the citizen to waive such right, they themselves may be demanding something they value more than a degraded environment. The challenge of law in this regard will be to seek to prevent much socially desirable environmental degradation and permit only extremely profitable instance.

A major challenge to sustainable development is to treat the environment as public trusts. This policy option requires full use of the environment's capacity to assimilate pollutants as well as prohibiting activities permanently impairing the environment. The reasons for this argument are given as follows: "Some resources are so important for the well-being of all individuals that it is unwise to allow private ownership of them; many of these resources flow from function of government is to promote common interests instead of permitting such vitally important resources to be shifted from broad common uses to the promotion of private gain" (Sax, 1971).

The difficulty is that even though the public trust doctrine has implications that fit very well with the proper goal of environmental protection policies, and the fact that it offers a broad legal framework into which other aspects of environment policy can be fitted, it does not provide how the prohibition of excess pollutants is to be enforced.

The goal of the National Policy on the Environment of Nigeria is to achieve sustainable development in Nigeria and in particular to:

a. Secure a quality of environment adequate for good health and well being;
b. Conserve and use the environmental and natural resources for the benefit of present and future generations;
c. Restore, maintain and enhance the ecosystems and ecological processes essential for the functioning of the biosphere to preserve biological diversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystems;
d. Raise public awareness and promote understanding of the essential linkages between the environment, resources and development, and encourage individual and community participation in environmental improvement efforts; and

e. Co-operate in good faith with other countries, international organisations and agencies to achieve optimal use of transboundary natural resource and effective prevention or abatement of transboundary environmental degradation (NPE, 1998).

Environmental protection and management can only be effective if there is proper environmental education that can create the right awareness and ethics in mankind that will foster the needed harmony with the environment and guarantee sustainable development and continued human existence and welfare. Thus, it has been stated by MANASC (1996), that:

> Proper education of citizen (will) prepare them for facing challenges to ensure a positive future for all, by creating in the people an open or liberal frame of mind that recognizes and finds solution to problems…. Environmental education is designed to develop and produce a citizenry that is aware of and is concerned about the citizens' total knowledge, attitudes, motivations, commitment and skills to work individually and collectively toward solution of current problems and the prevention of new future ones especially in the immediate environments.

VII. CONCLUDING REMARKS

This paper has argued that paying more attention to the interactions between the rural communities and protected forests and reserves is needed in the study area, mirroring concern with poverty and conservation linkages elsewhere. Also, this paper has shown that by numerous measures, the majority of people in the rural communities surveyed relied on the nearby protected forests for both cash and subsistence goods, even though they were primarily identified (by themselves and by others) as local farmers. The farmers used the forests for extraction of a diverse number of forest products, indicating that the pressure on protected forests in the study area does not always come from land expansion from farmers alone. The study reveals that the members of the communities not doing well in agriculture or who had no sources of off-farm cash income tended to have the highest levels of dependency on forest resources.

Better information on and attention to such details about forest use in rural communities of Benue State is particularly needed as laws are being strengthened to make the collection of products from protected forests increasingly difficult. At the time of the study, because enforcement actions were unevenly directed, many people continued to freely collect forest products like bamboos, medicinal and leaves without fear of reprisal. Such openness was tenuous, however, as forest guards or rangers could at any time decide to strictly enforce the national laws prohibiting forest extraction from the protected forests and reserves. Without recognition of the links between farming and forest extraction, the enforcement of conservation laws may appear to be easy and to affect few people (because no one was actually living in the forests under study), but in fact could put some nearby farmers into financial difficulty. This is not to argue that enforcement is not needed or there would be no conservation benefit if the forests were better protected. Indeed, several activities, such as charcoal making, burnt-bricks making and hunting, had high conservation impacts. And while this study did not attempt to value the ecosystem services provided by the forests to the nearby farmers, it is likely that continued loss of forest cover might indeed impose costs on households who are dependent on the forests. Furthermore, this paper argues that conservation interventions need to be coupled with attention to who will be most affected in order to ease the transition to conservation and not lead to increased levels of hardship.

The problem, however, is that little attention has been paid to these poverty-conservation conflicts, as they are often overlooked in any discussions. For example, a recent document of the World Bank highlighted the need to pay attention to conflicts between protected forests (many of which are eligible for special conservation funding loans from the Bank) and local populations' use of these forests, but the Bank's concern was limited to a discussion of ethnic minority populations in order to be in compliance with the Bank's overall indigenous peoples policies (World Bank EASRE 2003). Farmers who are not ethnic minorities are often not recognized as being in any special need of attention or care with regard to forestry policy. Yet as this paper has demonstrated, Benue rural communities or peasants around protected forests also may have high levels of dependency on forest resources. More studies like this one are needed to expand knowledge in Nigeria and elsewhere on how economically linked communities may be to nearby protected forests, and how conservation interventions benefiting both the forest and dependent communities might be designed.

As stated above, forest ecosystems are extremely efficient systems both for holding and recycling nutrients and for absorbing and holding water, because they maintain and protect very porous, humus-rich topsoil. Therefore, converting a hillside from forest to grassland resulted in doubling the amount of runoff and the leaching of nutrients increased many fold. Much worse is what occurs if the forest is simply cut and soil is left exposed. Pounding raindrops quickly seal the soil; the topsoil becomes saturated with water and slides of the slope in a muddy mass into water ways, leaving barren subsoil that continues to erode. In other words, when the forests are cleared, the thin layer of humus with nutrients readily washes away. Only the nutrient, poor clayed subsoil, which is very poor for agriculture is left. This represents the picture of the situation in the study area. It can therefore be said that the most serious problem facing the in the study area forests is deforestation. When forests are destroyed, they no longer make valuable contributions to the environment or to the people who depend on them. Forest destruction also threatens native people whose cultural and physical survival depends on the forests. Therefore, the following recommendations are suggested in order to arrest deforestation and depletion of natural resources in the protected forests and reserves in the study area.

First is the provision of alternative sources of energy to the people of the area. The use of firewood as the major domestic energy for cooking constitutes one of the critical factors of deforestation and desertification in the study area. It is therefore very necessary to find an alternative to the use of firewood. The scarcity and cost of kerosene in most cities also accelerates deforestation, as most city dwellers competes with the inhabitants of villages for the available firewood. The following alternative methods are suggested to solve the problem posed by the use of forest produce as firewood.

(1) Promoting community forestry projects in which representatives from each house-hold learn to encourage other villagers to plant, tend, and harvest local woodlots, with the wood distributed among the households and proceeds from any marketable surplus used to support community development projects.
(2) Having government forest guards act as extension agents to help communities by providing seed or seedling for firewood planting stock and advice on tree care.
(3) Planting appropriately selected fast-growing firewood trees and shrubs in unused patches of land.
(4) Using agro forestry to grow both crops and fast growing fire wood trees in the area.

(5) Helping to conserve wood energy by developing more efficient wood stoves, solar cookers, and small biogas plants that produce methane gas from organic wastes and leave fertilizer ash as a by-product.
(6) Practicing population control to help keep local population in balance with renewable resource capabilities.

Note that the above-suggested methods of alternative sources of energy are also appropriate for solving the problem of firewood scarcity within the society. In this regard, the use of coal has been proved to be suitable, cheapest and environmentally friendly next to firewood.

Secondly, there is need for Silviculture cultivation to produce renewable timber resources. Since one of the most effective methods of combating deforestation and desertification is through the planting of trees, species of wood traditionally used by the local people as fuel should be brought to cultivation through domestication. Equally important is that economic indigenous trees should be used so as to attract the active participation of the rural dwellers in the tree-planting programme.

In addition, there is need for the provision of alternatives to forest products use in the study area. For example, the use of wood in the construction industry is also another factor that is responsible for deforestation and desertification. The abundant use of wood or planks in scaffolding and decking during construction should be substituted with metal. If the use of metal in scaffolding is promoted, a lot of trees will be saved. Thus, the use of environment friendly substitutes for forest products should be intensified and encouraged.

Fourthly, population control should be pursued vigorously by the government as this has been identified as militating against environmental degradation. For example, Nigeria's population continues to witness explosion with an average population growth rate of 2.8% per annum, Nigerian's population is projected to reach about 238.4 million by the year 2025 (UNFPA, 1997). With the fall in infant mortality rate from 131 per thousand between 1970–75 to 93 between 1990–95, population continues to grow astronomically. The effect of such rapid population growth rate against the limited resources, and crude technology is the imposition of additional strain on the infrastructure and increased environmental degradation. The effect is that a mismanaged demographic development will ultimately strain the crucial balance between people, resources and the environment which may hinder capacity to improve human condition. A population explosion will lead to increase in food demand which will inevitably lead to increase in land degradation and fragmentation, over-utilisation of agricultural and grazing land and deforestation. It will also increase waste generation and energy consumption.

Furthermore, in addition to the general control of forestry exploitation, emphasis should be geared towards the enforcement of existing national laws and conventions, especially those of the United Nations to which Nigeria is a signatory. One of such laws is the Forestry Law, 1963. By section 50 thereof, whoever in any forest reserve except with the authority in writing of the prescribed officer do any of the under mentioned acts shall be liable to a term of imprisonment of twelve months or a fine of ₦100.00 or to both. These acts are as follows; whoever –

(a) takes any forest produce;
(b) uproots burns, strips off the bark or leaves from, or otherwise damage any tree;
(c) sets fire to any grass or herbage, or kindles a fire without taking due precaution to prevent its spreading;

(d) smokes or lights a fire in any part of a forest reserve within which, or at a time when, smoking or the lighting of fires is prohibited by an order of the minister or a nature authority;
(e) pastures cattle or permits cattle to trespass;
(f) digs, cuts, turns or cultivates the soil or makes a farm or plantation;
(g) trespasses in any part of a forest reserve in which trespass shall be prohibited by an order of the minister or a native authority or during any period specified in an order of the minister or a native authority;
(h) construct any dam or weir across any river or stream or otherwise obstructs the channel of any river or stream;
(i) resides or erects any building;
(j) hunts or fishes;
(k) damage in any way or destroys any forestry property.

In addition, section 52 of the same law which deals with offences in protected forests provides that whoever within a protected forest, except with the authority in writing of the prescribed officer-

(a) uproots, fells, or otherwise damage any protected tree of over two feet in girth;
(b) otherwise than during the period of year allowed for this purpose, either sets fire to or allows fire to spread to any forest growth unless such forest growth is being or has been felled for farming purposes;
(c) contravenes any of the provisions of paragraph (b) of Section 19, shall be liable to a fine of ₦50 or imprisonment for six months. The said section 19 prohibits the acquisition of new rights in land to be constituted as a reserve. In particular, it states that:
(i) no new house shall be built;
(ii) no tree shall be cut; and
(iii) no forest produce shall be removed.

Under section 60 of the Law, in addition to any penalty imposed for an offence against the provisions of the Law or any regulations made under it, the court may order

(a) any forest produce in respect of which the offence was committed or any instrument or thing with which the offence was committed to be forfeited and disposed of as the court may direct;
(b) any farm or plantation made in a forest reserve in contravention of section 50(f) to be destroyed or, on the application of the Chief Conservator of Forests, that any such farm be confiscated and thereafter disposed of in the discretion of the Chief Conservator of Forests;
(c) that any licence or permit held under the law shall be cancelled; and
(d) that, where no licence or permit has been taken out and the offender should have taken out a licence or permit, a fee equal to the amount of the fees and royalties that should have been paid in respect of such permit and licence, be paid to the authority or person who would otherwise have been entitled to such fee or royalty.

The problem with this law is that the penalties provided are too small to act as deterrence to any offender. Moreover, litigation is a powerful and effective private and public tool for compelling compliance and imposing consequences for violating the law, accomplishing remediation of the damaged environment and securing compensation from the offender. In the realm of public

enforcement of environmental law, although, legal action is the most important means of enforcement, it is usually pursued as a last resort. It may be pursued through administrative measures, civil law application of liability rules, or by imposing criminal sanctions. Although the statute created several environmental offences, the power of prosecution is not directly vested in the Environmental Protection Authorities but on the Attorney General of the Federation or State as the law officer of the Federation or the State. The Environmental Protection Authorities are left with the mere responsibility to regulate media of pollution, information gathering and analysis, search and seizure of incriminating evidence for possible prosecution (which they do not control). The inevitable drawbacks of this strategy are excessive bureaucratic centralization, rigidity, excessive cost and delay. It is therefore the belief of this paper that establishing a National Environment Court will assist in no small measure in alleviating these problems.

In other to make the enforcement of these laws effective, there must be massive public awareness campaign and adduction on the causes and dangers of deforestation and desertification as well as promoting sustainable agricultural practices. To this end, the objectives of the Natural Resources Conservation Council as contained the Act, Cap. 286, 1990 should be pursued with renewed vigour. The Council's mandates under the Act include:

(a) Monitoring the Conservation programs and projects of other agencies and helping to avoid resolve conflicts.
(b) Taking fiscal measures to encourage the conservation of natural resources.
(c) Designating and insuring the protection of habitats and species of special conservation interest.
(d) Making special awards to projects serving national conservation goals and funding scientific assessments of the ecological impacts of projects.
(e) Helping control coastal zone development and minimise coastal erosion (see Sections 1 and 3).

In conclusion, there is need for the establishment of National Desertification and Deforestation Control Commission: The setting up of Commission will go a long way in solving some of the ecological problems in the study areas and indeed, Nigeria. The Commission, if set up, will be responsible for coordinating all the efforts and implementing the strategies to combat the problems of desertification, deforestation and erosion that are ravaging various part of this country. The Nigerian environment is becoming an endangered ecological area as manifested by soil erosion, soil nutrient depletion, degraded mines land, deforestation, floods, desert encroachment and poor soils due to bush burning and municipal waste. However, if the above measures are efficiently and faithfully implemented, it will restore the soil fertility in the affected areas. Other benefits will include the boosting of food production and livestock in the country. Equally important is the fact that when the lands are reclaimed and enriched, rural – urban drift can be stopped thereby, reducing the threats posed by the urban unemployed and the rural immigrants. With good and effective afforestation programme, more grazing lands will be developed thereby enhancing national food and protein supply of the Country.

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The Roles of the Community, Private Sector, and Local Authority in Recycling in Bangkok's Gated Communities

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Abstract:

Recycling, proposed by the UN as one of the means to achieve sustainable development, has not been practiced sufficiently in Bangkok households. This research focuses on recycling in Bangkok's gated communities of which their prevalence and consuming-class residents render them an ideal target group for a source separation program. The goal is to understand the roles of the three stakeholders in gated-community recycling. These are the gated community, the private recycling agent, and the local authority in charge of waste management.

Findings found the first two stakeholders to play an active role in the community recycling program as residents sort waste to be collected for sale to private recycling agents, in the absence of a formal recycling system. Regarding the gated community, social capital - in the aspects of the community's committee, its staff, its pro-recycling leader, volunteers, and networks - and convenience especially of having a sheltered storage area for recyclables, play a crucial role in the program's success. Regarding the private recycling agent, its availability and reliability is crucial. Regarding the local authority like the Bangkok Metropolitan Administration (BMA), it plays no role in the gated communities' recycling program, although the research points out that the BMA should actually play a role to improve the current situation.

Findings reveal three potential factors preventing the BMA from contributing more to recycling. The first is the lack of commitment from policymakers caused by the constant change of leadership, the huge workload faced by trash collection units, and the lack of public awareness. The second is the impracticality of the BMA in issuing regulations to support source separation due to the lack of real mandate and the absence of a supportive system. The third is the potential conflict of interest on the part of different participants in the informal recycling system.

1. Introduction

The soaring amount of solid waste in Bangkok is one of the impacts that the capital faces as a result of its economic growth, thus potentially undermining the sustainability of its development. Due to rapid urbanization, Bangkok residents indulge in a high consumption level resulting in household solid waste of 88% of the 9,000 tons of waste collected daily by the Bangkok Metropolitan Administration (BMA) – the Bangkok authority (Arora, 2010 & Chotthong, 2001). Most of the waste is disposed of in landfills outside Bangkok (Chotthong, 2001). Such an end-of-pipe solution of waste management costs over US$ 100 million annually (Jungrungrueng, 2011). And while the proportion of recyclables in the waste stream is as high as 30-40% ("Governor Abhirak", 2005), household recycling rate is only 1% (Muttamara et al., 2004)[1] even though households produce the biggest amount of Bangkok's municipal solid waste. It is clear that households need to engage more in source separation. This research focuses on recycling in middle-class households due to the high consumption level of such class and its large base, by narrowing down to target Bangkok's gated communities because of the abundance of these middle-class communities[2] and the clustering of households within them, which enables a recycling campaign to reach residents *en masse*.

The research was conducted on gated communities that have joined a recycling scheme with one organization called TIPMSE[3] which promotes recycling by teaching residents how to sort trash and providing free sorting bins and promotional materials. There are three stakeholders in the recycling scheme. The first is *the gated community* with its members including residents, committee members[4] elected among residents, and the hired community staff[5]. The second is *the private recycling agent* that goes into the gated community to buy recyclables collected by the community staff. The third *is the BMA* which is the local authority in Bangkok in charge of waste management[6]. (See Appendix A for the diagram showing the dynamics between the three stakeholders.) The aim of the research is to find out factors associated with each stakeholder that determine the success and failure of the gated-community recycling project.

[1] Most of the recycling activity is done instead through the informal sector (Manomaivibool, 2005) via scavenging, waste picking, and en route sorting by trash collection crews. However, minimal source separation by households renders such downstream recycling less effective due to a high level of cross-contamination of waste.

[2] According to data from the Bank of Thailand, over the past 20 years alone, there have been approximately 900,000 newly registered households within gated communities in the Bangkok Metro Region (Bank of Thailand, 2011).

[3] TIPMSE (Thailand Institute of Packaging Management for Sustainable Environment) is a not-for-profit outfit promoting recycling since 2008. It is funded by a consortium of manufacturers in the packaging industry in Thailand. Essentially, it is part of the industry's CSR.

[4] Their terms usually last for 2 years. A committee is in charge of deciding on key issues that affect the community and its members.

[5] These community staff are hired to run the administrative tasks for the community, e.g., distributing community newsletters, collecting homeowner fees from residents, maintaining common areas, etc.

[6] Within the BMA, responsibilities for wastes management are divided between the 50 District Offices with their trash collection units in charge of waste collection in the field, and the Environmental Department in charge of setting policy plans and supporting the waste collection work of the District Offices (Sungsuwan, 2007).

2. Research Objective

The research objective is to determine success factors and challenges that drive the outcome of recycling projects in Bangkok's gated communities.

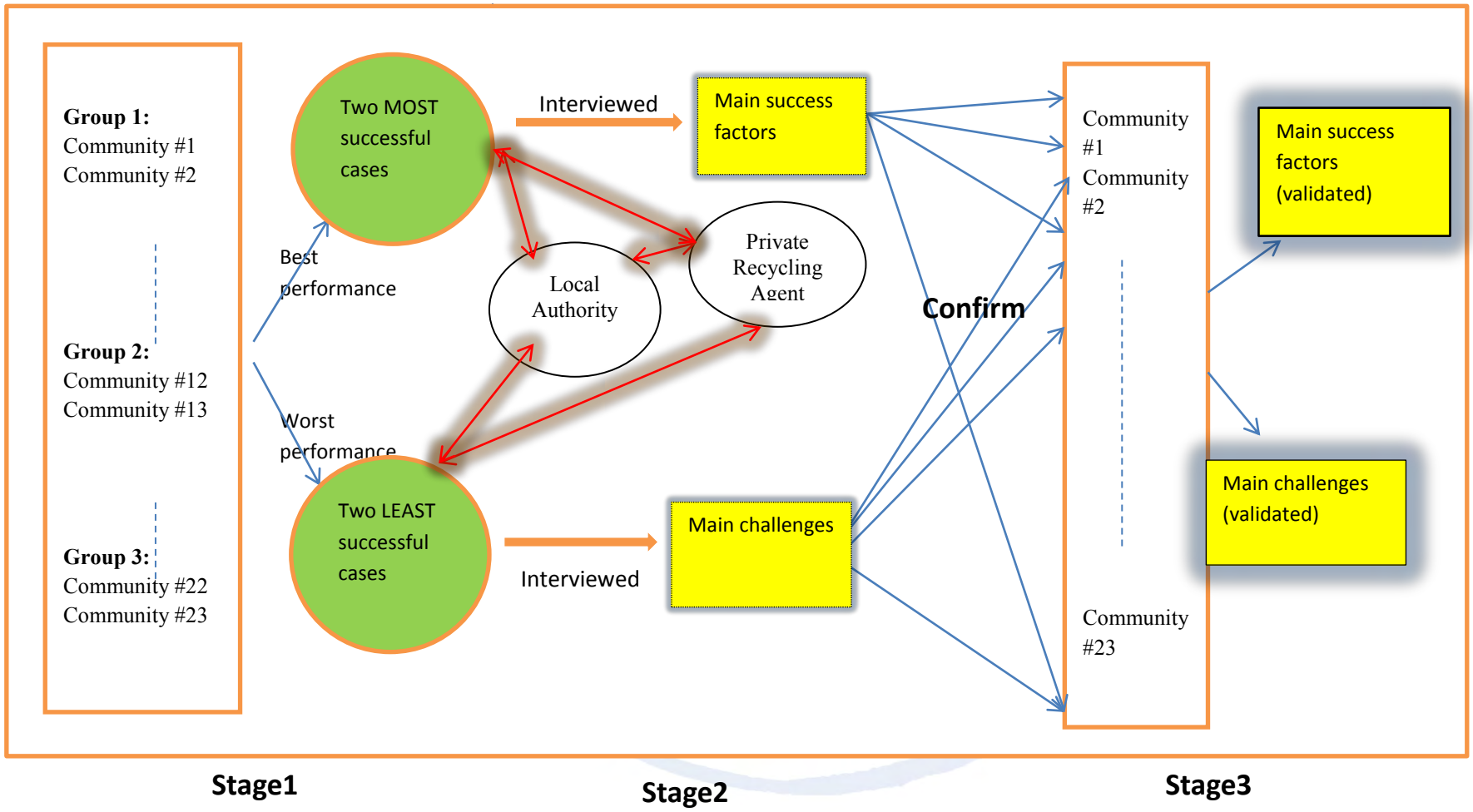
3. Research Methods

The research employed qualitative method relying on semi-structured interviews with members of the three stakeholders. A total of 69 people[7] from all three stakeholders were interviewed. Twenty three gated communities in the Bangkok Metro Region (BMR) that have joined TIPMSE's recycling program were used in the research. Based on the household participation rate[8] of each community, these 23 gated communities were separated into 3 groups – A, B, and C -- representing the best-, medium-, and worst-performing groups respectively. (See Appendix B for recycling performance and group assignment of gated communities in the research.) Four gated communities – two that succeed and two that have failed in the recycling project -- were then chosen for case studies. These are Maeg Mai and Sin Sup from Group A, and Discovery Bali Hii and Laddawan (Pinklao) from Group C. Based on the four case studies, success factors and challenges of the community recycling project were identified (see Section 4.1). Results were then validated among the rest of the 23 gated communities to confirm whether findings could apply to a bigger population (see Section 4.2). The overall research process is shown in Figure 3.

[7] 50 interviewees are members of gated communities; 17 are from the other two stakeholders, and 2 are from TIPMSE.

[8] The participation rate is the number of households that join the recycling program divided by the number of all households within the community.

Figure 3: Overall Research Process



4. Key Findings

4.1 Summary of Findings from 4 Case Studies

In this section, findings from all 4 case studies will be discussed on the basis of the three stakeholders as follows. (See Appendix C for findings from all gated communities in the research, including those of the 4 case studies.)

4.1.1 The Stakeholder – The Gated Community

All 4 case studies point to social capital and convenience especially of having sheltered storage on site as main factors determining the outcome of recycling. The two case studies of the best-performing communities (Maeg Mai and Sin Sup) are shown to possess social capital -- in five aspects being supportive committee, supportive staff, strong pro-recycling leadership, volunteers[9], and networks[10] – and convenience of having sheltered storage for accumulation of collected recyclables before they are sold to agents[11]. In stark contrast, the two case studies of the worst-performing communities (Bali Hii and Laddawan Pinklao) are shown to lack both social capital and the sheltered storage area. In addition, economic status[12] might potentially have influence on recycling outcome since one of the best performing gated-communities happens to be in the lowest economic status while one of the worst-performing communities is in the highest economic status.

4.1.2 The Stakeholder – The Private Recycling Agent

In all 4 case studies, private recycling agents are readily available. Such availability was cited by informants in all 4 case studies as an important factor as it makes possible the sale of recyclables. Agents' reliability was also important as the lack thereof was cited by informants at Maeg Mai (the 1st case study), Sin Sup (the 2nd case study), and Laddawan (the 4th case study) as a challenge that negatively affects recycling efforts in their communities.

4.1.3 The Stakeholder – The Local Authority

In all 4 case studies, the BMA as the local authority was found to play no role in the current gated-community recycling program, other than the informal sorting by its crews during routine trash collection. Information gathered from interviews with informants at the BMA's district offices shows that such an absence of role can be attributed to the authority's lack of firm commitment in promoting recycling in gated communities[13], the lack of regulation on

[9] Residents who help the pro-recycling leader (if one exists within the community) promote recycling within their community.
[10] An aspect of social capital achieved when the pro-recycling leader reaches outside of the community to acquire resources and knowledge to help with recycling efforts in the community.
[11] Most agents will only come in to the community to weigh and buy recyclables when the amount is big enough to be worth a trip.
[12] Here, economic status is based on the average land sizes of homes in gated communities.
[13] Most communities that are the target of the BMA's recycling campaigns are in lower-income strata -- mostly crowded non-gated communities and local schools. The reason for this is because these residents are more likely attracted by the extra income they gain from selling recyclables, and because overflowing trash in public areas is an incessant problem in these communities. Note that in these campaigns, the BMA trains communities how to sort and manage their own waste (i.e., sorting recyclables for sale later to informal recycling agents, and making liquid fertilizers out of food waste), albeit without the authority putting an official system in place to handle recyclables in the communities. This model is unlikely to appeal to gated communities where residents are

recycling, and huge workload constantly faced by trash collection units resulting in their focus solely on the routine trash collection operation and not on recycling.

4.2 Confirming Findings among All 23 Gated Communities

In this section, findings from all the 23 gated communities will be discussed on the basis of the three stakeholders, in order to confirm whether they are in line with findings from case studies. (See Appendix C for findings from all gated communities in the research, including those of the 4 case studies.)

4.2.1 The Stakeholder – The Gated Community

Regarding social capital, all gated communities in Group A (the best-performing group) have social capital in at least 2 out of 5 aspects -- supportive committee, and supportive staff -- with the two case studies of the best-performing gated communities possessing all 5 aspects. On the other hand, almost all of Group C's gated communities lack the five aspects of social capital. Therefore, it can be concluded that social capital is an important factor that determines success or failure of recycling outcome.

Regarding the factor about convenience in terms of sheltered storage area, while all gated communities in Group A either have the storage or have no need for one due to same-day transaction of recyclables collection and selling, 4 out of 9 gated communities in Group C and one out of 5 in Group B lack such storage. Therefore, it can be inferred that communities need storage to be successful in recycling; however, the existence of such storage is not the sole factor because many communities still fail in recycling in spite of it.

Regarding economic status, the result is mixed as there is no clear trend that emerges among the 23 communities (see Graph in Appendix D). However, the trend is clearer among the two communities with smallest-sized homes (Sin Sup and Prueksaville Rattanathibes) and the one with the biggest homes (Laddawan Pinklao) where the first two communities find success in recycling whereas the latter one failed. Further research involving a larger number of communities in very low and very high economic status would be needed before the correlation between economic status and recycling performance can be firmly concluded.

4.2.2 The Stakeholder – The Private Recycling Agent

For aspects associated with private recycling agents, locating recycling agents to conduct recycling transaction with seems hardly a problem for gated communities throughout the research, since all but one of the 23 communities show that they have agents readily available to them. In terms of agents' reliability, the lack of reliability appears in some communities in both the successful and failed groups. It may be inferred then that the lack of reliability may further hamper recycling efforts in communities where the social capital and convenience factors are already lacking (Group C), while such a lack of reliability is outweighed by other success factors when the latter exist (Group A). For Group C, the lack of agents' reliability may also be the result, rather than the cause, of non-commitment on recycling from gated communities.

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economically better-off, and where trash is usually collected completely so there is no issue of overflowing trash in public areas.

4.2.3 The Stakeholder – The Local Authority

Findings from all gated communities point in the same direction as those of the 4 case studies in that none of the community members perceived the authority as playing any important role in the recycling project of their communities. Although it may be tempting to assume that communities can succeed in recycling even without the involvement from the authority as is the case for communities in Group A, in the long run, it is difficult to imagine how the recycling effort could be sustained without support from the authority. Note that most community informants stated that, after the surge in the first year, participation rates remained constant at best, and in many cases drop. This is due likely to the fact that the two most crucial aspects of social capital found in the research – support from the committee and the staff – are difficult to sustain because of the 2-years term limit of the committee, and the pressure on the staff to give priority to their main tasks of ensuring security and upkeep of the community. Note also that even in the most successful group, the average participation rate of households that recycle is no more than 30 percent. Not to mention that most other communities in Bangkok do not even have a community recycling program set up. As such, it is clear that the BMA has an important role to play in raising public awareness and in setting up a system that facilitates household recycling. At this point, the research turned the focus towards the BMA in order to shed some light on the potential causes that lead to the current absence of their role in recycling. It found three underlying causes:

The first is the lack of continued commitment by policymakers on recycling, despite seemingly continuous high-level policies on recycling. This is a result of multiple reasons such as the constant change of leadership at the BMA resulting in lack of continuation of recycling campaigns, the huge workload faced by trash collectors in the field thus preventing the trash collection units from taking up more tasks such as training communities on recycling or making extra rounds to collect recyclables, and the lack of public awareness and participation resulting in cancellation of many campaigns.

The second is the impracticality of the BMA in issuing regulations on recycling, even though regulations are shown to be in place in many regions where recycling is more successful such as Belgium (Matabang, 2007), Switzerland (“Recycling Around the World”, 2005), the U.K. (Druce, 2007), certain states in the U.S. (Charbonneau, 2009; “Bottle Bills”, 2010; Skumatz & Freeman, 2006), Japan, South Korea and Taiwan (Terazono et al., 2005), or even a small city in the Philippines (Atienza, 2005). Key informants at the BMA pointed to two reasons for the unwillingness of the BMA in issuing regulations encouraging recycling. One is the lack of supportive system, e.g., it is no use enforcing a recycling law on the public when there is no complete system to take care of sorted waste, both en route and at transit sites. The other important reason is the BMA’s lack of real mandate in issuing regulations. Even though, in principle, the Public Health Act of 1992 grants the BMA the authority to issue regulations concerning all matters of waste management; in practice, the legal system is incomplete in the sense that the BMA has limited to no mandate when it comes to regulating the private sector whose collaboration is crucial for recycling to be successful. At this point, it is clear that regulations at the national level, and those that address the private sector, are important in supporting public recycling policies at the local BMA level.

The third cause which needs further research is the potential conflict of interest from different parties that may stand to lose if households engage in extensive source separation. One important group is the trash collection crews who have been earning extra income from

sorting trash en route during trash collection time[14] to make up for their low wage. At the policymaker level, it may be possible that the prevalent practice of informal en-route sorting by trash collectors adds to reasons for policymakers to see no point in extensively promoting household source separation, even though the gain from mid-stream sorting by trash collectors should be weighed against the loss in trash collection time, thus aggravating the already endemic problem of trash being left uncollected due to overwhelming workload as cited in all case studies, as well as against the ensuing problem when the public resorts to trash burning which usually happens when trash is left to rot. Moreover, en route sorting cannot be done efficiently because trash is mixed up when there is no source separation, and because of the tight schedule.

Another group that can potentially cause conflict of interest is the large private recycling shops at the perimeters of waste transit sites because they also run a lucrative business of lending money to trash collection workers who pay back loan with materials recovered en route, and the private contractors who operate waste transit sites because they run a business of letting registered scavengers into the site and either getting fees from these scavengers or purchasing retrieved recyclables from them at the price they set. Further research will be needed to determine the influence that these parties have on the policymakers' decision to push for extensive household source separation, which might threaten the business as usual of the parties presently involved.

5. Conclusion

Source separation and recycling is one of the important means to ensure that the increased material consumption that comes with economic growth does not compromise the sustainability of the environment, which is one of the three key components of sustainable development (UNCED, 1992). This thesis focuses on the recycling program in Bangkok's gated communities due to the abundance of such communities in Bangkok, the clustering of households within them, and their consuming-class residents. Such communities are also symbolic of the growing middle class that is the fruit of urbanization in rapidly industrializing cities of developing countries. As such, findings from this research can contribute to the body of knowledge that can be used to support recycling and sustainable development in Thailand, as well as that in mega cities of other comparable developing countries.

The research concentrates on three actors with stakes in community recycling, namely: the gated community itself; the private recycling agent which buys recyclables from the community; and the BMA -- the local authority in charge of waste management in Bangkok. Only the first two stakeholders were found to play an active role in the community recycling program, as residents of gated communities sort waste to be collected for sale later to private recycling agents (who, in turn, sell waste to bigger recycling shops or factories), thus allowing recycling activities to take place in the absence of any role played by the third stakeholder, the local authority.

Regarding the gated community as one of the stakeholders, findings show that, social capital -- in the aspects of supportive committee, supportive community staff, pro-recycling

[14] It is estimated that the BMA's trash collectors recover around 400 tons of recyclables per day (Manomaivibool, 2005).

leadership, volunteers, and networks -- plays the most crucial role in determining the outcome of recycling, with the first two aspects being the most crucial. The second-most important factor is convenience that facilitates recycling, especially in the form of a central temporary sheltered storage area where collected recyclables can be accumulated until the amount is big enough to make a sale.

With regards to the private recycling agent, the recycling project of the gated communities mainly owes its existence to this second stakeholder as recycling agents buy and sell recyclables, thus allowing such waste to be brought back into the production system. The agents' availability, therefore, is crucial. The reliability of the agents, on the other hand, seems to be a success factor but to a lesser extent than others, due likely to the fact that gated communities can switch to other agents when their agents are found to be unreliable.

Regarding the local authority which is the third stakeholder, the research found that it has not played a role in supporting the informal recycling program in the gated communities studied. However, by pointing to the participation rates that are stagnant over the years in all communities in the research, to the unlikelihood that communities could sustain social capital in the long run especially in the aspects of the supportive committee and staff, and to the fact that the majority of gated communities in Bangkok still do not have a recycling program in place, the research suggests that there is a role that the BMA should play to improve the outcome of household recycling overall.

As such, the research then sought to determine possible factors that have been preventing the BMA from contributing more to recycling programs. It has identified the first factor to be the lack of continued commitment from policymakers on recycling, which is caused by the constant change of leadership, the huge workload faced by staff in the field, and the lack of public awareness resulting in cancellation of many recycling campaigns. The second factor is the impracticality of the BMA in using regulations to support source separation and recycling due to the absence of a supportive system even if regulations are in place, and the lack of real mandate in issuing such regulations. Based on this, the research suggests that regulations at the national level are needed to support recycling policies at the local BMA level. The third factor which needs further research is the potential conflict of interest, on the part of different participants in the informal recycling system, which may influence policymakers' decision to promote extensive source separation at the household level.

6. Recommendations

6.1 Recommendations for Gated Communities

- Consider investing in sheltered central storage.
- Consider allowing recycling agents to collect recyclables directly from in front of residents' homes, to relieve the workload of the community staff thus increasing the likelihood that the project will succeed long-term.

6.2 Recommendations for the Recycling Agents

- Purchase recyclables from multiple sources in the vicinity, by contacting several communities in the same area, in order to ensure that the amount of recyclables is worth the transportation cost. This thus increases the agents' reliability in picking up recyclables on schedule.

6.3 Recommendations for the BMA

In terms of gated communities, potential things that the BMA could do to help promote recycling programs include:

- Reach out to community committees to promote recycling
- Support materials for sheltered central storage
- Consider tying waste fees[15] to trash amount to provide incentives for participation

In terms of private sector, the BMA could support or encourage them as follows:

- Provide tax incentives for registered recycling agents
- Seek collaboration from private sector. For example, encourage home builders to construct facilities such as sheltered areas for use as central depots for recyclables

In terms of the BMA itself, actions that the BMA could take to address its shortcomings identified in the research findings include:

- Institutionalize its commitment to recycling by setting up a position within the BMA's Environmental Department specifically to promote recycling. That way, recycling programs would be insulated from any disruption that may be caused by the change of leadership.
- Conduct study on en route sorting done by trash collection crews in order to make an informed decision on whether or not to formally support such activities. If the study shows en route sorting to be more beneficial, the BMA could then devise protocol, set up proper training and allocate appropriate equipment for the job. Furthermore, formal evaluation can then be performed on en route sorting if the practice is integrated into the collection system. The BMA should also research the current supplementary income earned by the trash collection crews and determine the necessary level of compensation.

6.4 Recommendation for National-Level Policymakers

- Raise public awareness continually and strategically
- Consider subsidizing the prices of recyclable materials, especially those that are currently not being significantly sorted out through recycling, for example, plastic bags (due to its low price)
- Issue laws to regulate the private sector
- Provide tax incentives for businesses that engage in recycling
- Set industry standards
- Promote investments in recycling technology

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[15] Collection fee is limited to 40 Baht per capita per month. The fees collected cover only 3-10% of the operational costs of waste management (Muttamara et al., 2004).

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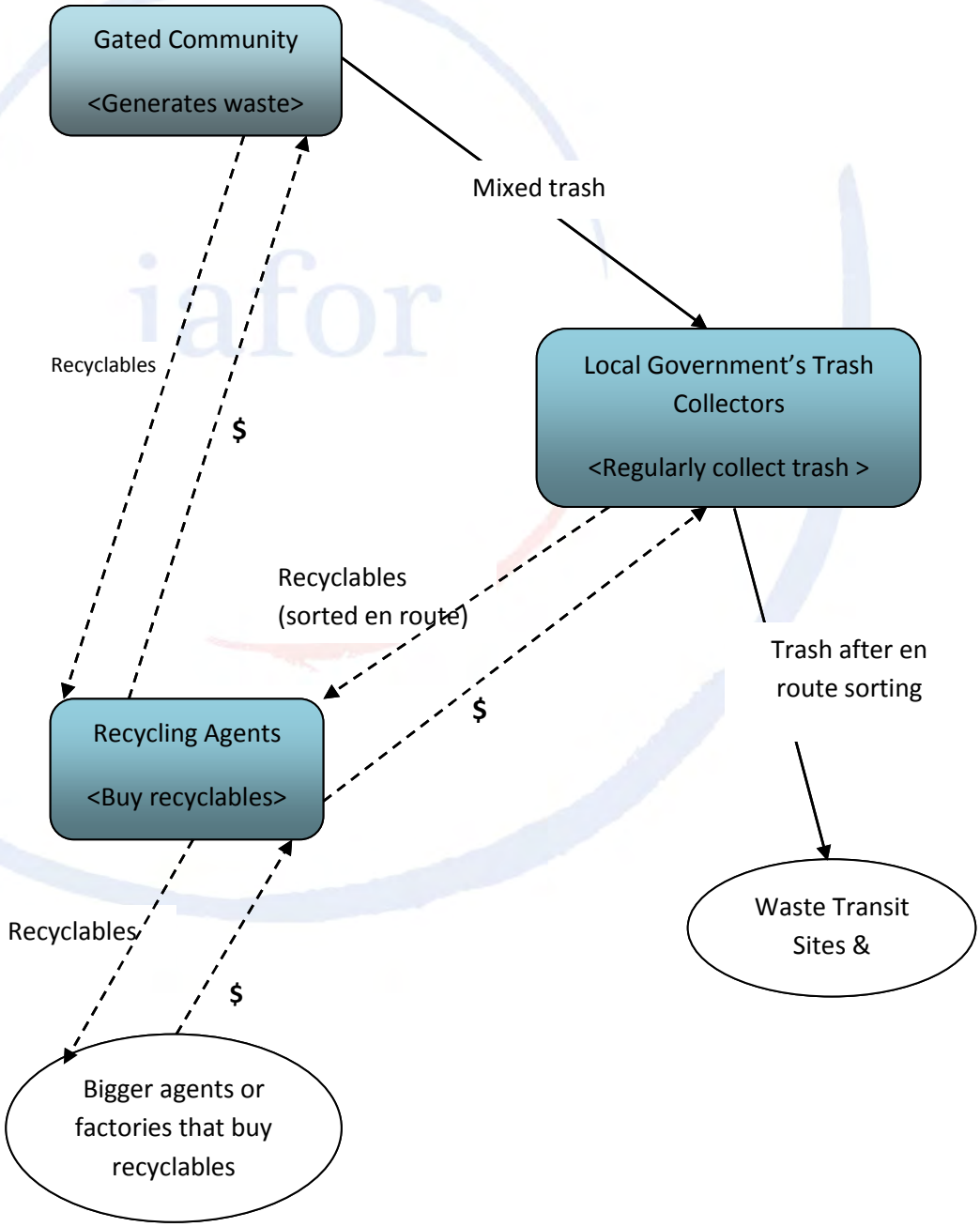
APPENDIX

Appendix A

Figure A1: Diagram of Dynamics between the Three Stakeholders



Appendix B

Table B: Recycling Performance and Grouping Assignment

No.	Gated Communities	Key Informant	Started	# Recycling Households[6]	# Total Households	%Participation Rate	Group
1	Maeg Mai (case study #1)	(Multiple)	2008	70	190	37%	A
2	Sin Sup (Case study #2)	(Multiple)	2009	300	900	33%	A
3	Chuan Chuen Resident	Admin manager & resident	2008	30	90	33%	A
4	Prueksaville Rattanathibet	Assistant Admin manager	2009	70	230	30%	A
5	Summagorn	Admin manager & resident	2010	60	200	30%	A
6	Floraville	Admin manager & resident	2009	240	1,600	30%	A
7	Chaiyapruek Suwinthawong	Admin manager	2008	80	270	30%	A
8	Nakarin Garden	Admin manager	2009	70	240	29%	A
9	Chaiyapruek Klong 2	Admin manager, resident & committee	2009	60	250	24%	A
10	Munthana Talingchun	Current & ex admin managers & residents	2009	40	250	16%	B
1	Discovery Balika	Resident & ex-	2009	35	230	15%	B

1		Admin manager					
12	Greenville	Resident & committee	2009	60	400	15%	B
13	Baan Fah Green	Committee member	2009	60	400	15%	B
14	Suchaya	Resident & committee	2008	15	190	8%	B
15	Kunalai	Admin manager & resident	2008	10	300	3%	C
16	Chollada Bangbuathong	Admin manager	2009			0%[8]	C
17	Seewalee	Admin manager	2009			0%	C
18	Nunthawan Talingchun	Resident & ex-Admin manager	2008			0%	C
19	Chaiyapruek Ramindra	Admin manager	2009			0%	C
20	Chaiyapruek Baangbuathong	Resident & ex-committee member	2009			0%	C
21	Private Ramindra	Resident & ex-committee member	N/A			0%	C
22	Discovery Bali Hii (case study #3)	(Multiple)	2008			0%	C
23	Laddawan Pinklao (case study #4)	(Multiple)	2010			0%	C

Appendix C

Table C: Summarized Findings from all the 23 Gated Communities (presented in the order according to their recycling performance)[16, 17]

(Note that the 4 case studies are Communities No. 1, 2, 22, and 23 below.)

			Stakeholder – Gated Community			Stakeholder -- Recycling Agent		Stakeholder -- Local Authority		
No	Gated Community	Group	Social Capital (L=Leader, C=Committee, S=Staff, V=Volunteers, N=Networks)	Convenience (S=temporary Storage, O=Others e.g., flexible pickup, bins)	Economic Status (using land size in sq. was as proxy)	Available	Reliability	Commitment in Gated-Community Recycling	Regulations on Recycling	Heavy Workload of Collection Crews[18]
1	Maeg Mai (Case Study#1)	A	Yes: L, C, S, V, N	Yes: (S)	70	Yes	No (sometimes)	***No***	***No***	***Yes***
2	Sin Sup (Case Study#2)	A	Yes: L, V, C N; No need for (S)	Yes: (S), (O)	20	Yes	No (sometimes)	***No***	***No***	***Yes***
3	Chuan Chuen	A	Yes: L, S, (C) No: (V), (N)	Yes: (S)	50	Yes	Yes	***No***	***No***	

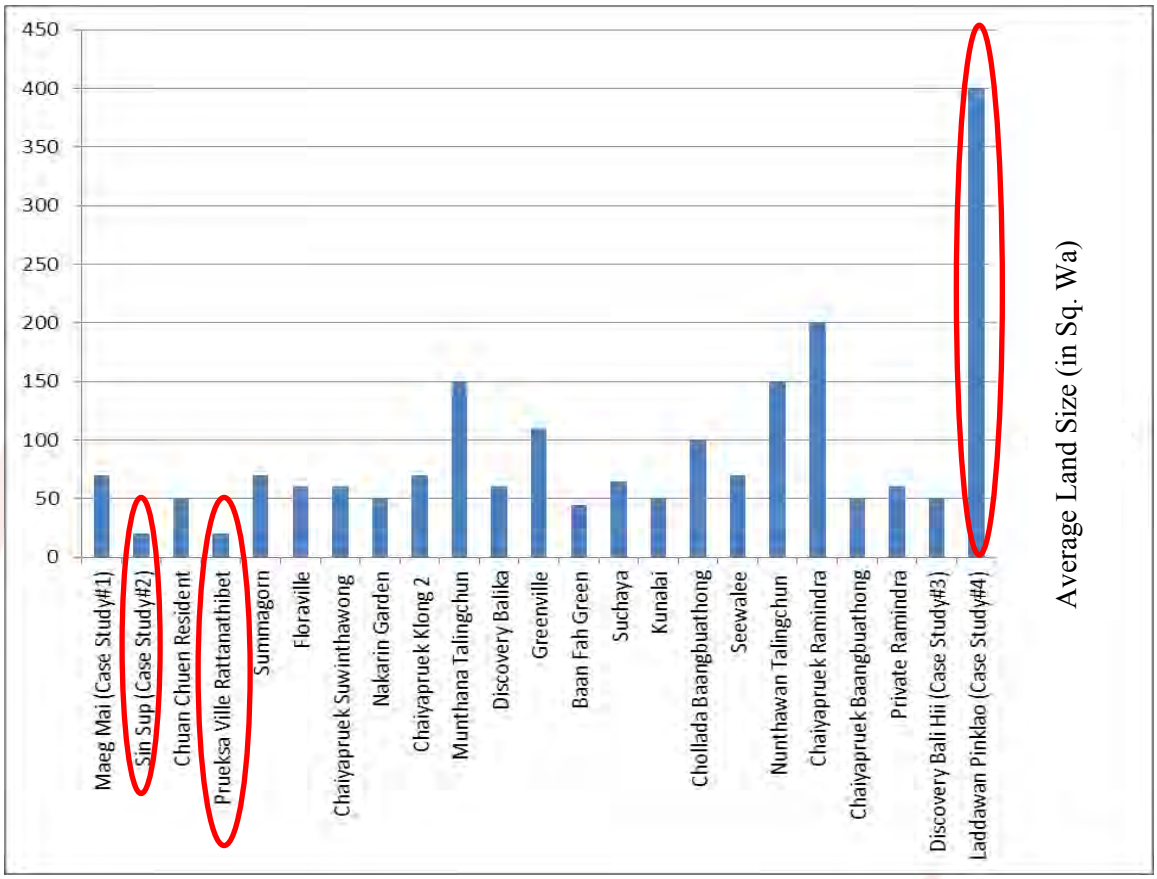
[16] This table summarizes findings from the 4 case studies in which multiple interviewees across stakeholders were interviewed, as well as findings from the other 19 gated communities in which key community members were interviewed, one member per community.
[17] Parentheses in the table indicate that although an aspect was not mentioned by the key informant, it exists nonetheless
[18] This information is only available in the 4 case studies because the local authority was not interviewed in the rest of the gated communities.

	Resident									
4	Prueksa Ville Rattanathibet	A	Yes: L, C, V, N No: (S)	Yes: S	20	Yes	Yes	***No***	***No***	
5	Summagorn	A	Yes: L, S, (C); No: (V), (N)	(no need for S)	70	Yes	No (sometimes)	***No***	***No***	
6	Floraville	A	Yes: L, C, S; No: (V), (N)	Yes: S, O	60	Yes	Yes	***No***	***No***	
7	Chaiyapruek Suwinthawong	A	Yes: C, S No: (L), (V), (N)	(no need for S)	60	Yes	Yes	***No***	***No***	
8	Nakarin Garden	A	Yes: S, (C) No: (L), (V), (N)	Yes: S	50	Yes	Yes	***No***	***No***	
9	Chaiyapruek Klong 2	A	Yes:, C, S No: (L), (V), (N)	(no need for S)	70	Yes	Yes	***No***	***No***	
10	Munthana Talingchun	B	Yes: C, S No: (L), (V), (N)	Yes: S	150	Yes	Yes	***No***	***No***	
11	Discovery Balika	B	No: L, C, (S), (V), (N)	Yes: (S)	60	Yes	Yes	***No***	***No***	
12	Greenville	B	Yes: C, S No: (L), (V), (N)	Yes: (S)	110	Yes	No (sometimes)	***No***	***No***	
			Stakeholder – Gated Community			Stakeholder -- Recycling Agent		Stakeholder -- Local Authority		
No	Gated Community	Group	Social Capital (L=Leader, C=Committee, S=Staff, V=Volunteers,	Convenience (S=temporary Storage, O=Others	Economic Status (using land size in	Available	Reliability	Commitment in Gated-Community	Regulations on Recycling	Heavy Workload of Colle

			N=Networks)	e.g., flexible pickup, bins)	sq. wa as proxy)			Recycl ing		ction Crew s
13	Baan Fah Green	B	Yes: L, V No: C, S, (V), (N)	No: S	45	Yes	Yes	***No***	***No***	
14	Suchaya	B	Yes: L, (S) No: C, (V), (N)	(no need for S)	65	Yes	Yes	***No***	***No***	
15	Kunalai	C	No: S, (C), (V), (N) Yes: L	Yes: (S)	50	Yes	Yes	***No***	***No***	
16	Chollada Baangbuat hong	C	No: S, (L), (C), (V), (N)	No: O, S	100	Yes	Yes	***No***	***No***	
17	Seewalee	C	No: C, (S), (L), (V), (N)	Yes: S	70	Yes	Yes	***No***	***No***	
18	Nunthawa n Talingchu n	C	No: L, C, (V), (N); Yes: (S)	No: S	150	Yes	***No***	***No***	***No***	
19	Chaiyapru ek Ramindra	C	No: L, C, (S), (V), (N)	Yes: S	200	Yes	***No***	***No***	***No***	
20	Chaiyapru ek Baangbuat hong	C	No: L, C, S, (V), (N)	Yes: S	50	***No***	***No***	***No***	***No***	
21	Private Ramindra	C	No: L, C, (S), (V), (N)	Yes: S	60	Yes	Yes	***No***	***No***	
22	Discovery Bali Hii (Case Study#3)	C	No: L, C, S,V, N	No: S	50	Yes	Yes	***No***	***No***	***Yes***
23	Laddawan Pinklao (Case Study#4)	C	No: L, C, S,V, N	No: S, O	400	Yes	***No***	***No***	***No***	***Yes***

Appendix D

Graph D: Economic Status Based on Average Land Size of Homes



Note: Average land size is used as an approximate proxy for economic status. The graph is sorted in the order of recycling performance (i.e., participation rates), from best to worst.

Micro Siting and Wind Energy Potential in Mersing, Malaysia Using RIAM-Compact

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The Asian Conference on Sustainability, Energy and the Environment

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Abstract:

This paper reviews the potential for wind-power generated electricity in ASEAN countries with special attention to Malaysia. ASEAN countries comprises of Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. Big progress in renewable energy most probably comes in wind, because ASEAN countries have big potential for wind energy as it occupies less land. Besides, land in these countries is quite fertile and has alternative uses, so it's not very conducive for solar. Wind resources map are widely available for Laos, Vietnam, Thailand, Cambodia and Philippines but there is not much information about other five ASEAN countries. Wind data was analyzed to study on the wind energy potential in Malaysia. Preliminary examination on selecting the specific location for wind turbine installation in Malaysia was done using FirstLook software. The most appropriate point for locating wind turbine in Malaysia is selected using RIAM-COMPACT numerical model developed for micro siting. This study is of interest not only to look into available and ongoing projects of wind energy in ASEAN countries but also for assessing the feasibility of using wind machines in Malaysia. It is concluded that for Malaysia in the foreseeable future the benefits of economic wind power electricity generation will probably be confined to small remote isolated installations.

1. INTRODUCTION

The awareness in promoting green technology has arisen significantly recently due to increasing issues pertaining to global warming. M**arkets for renewable Energy (RE) especially in wind energy, solar energy and biomass power projects for ASEAN countries are expected to obtain its high-growth trajectory in the coming years.**

The most potential energy in RE most probably comes from wind, because ASEAN countries have big potential for wind energy as it occupies less land. ASEAN countries comprises of Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam.

This paper first discussed the general review of the wind energy potential and current wind energy progress in ASEAN. It is then developed into a deeper study on the wind energy potential in Malaysia. The paper will give brief ideas on previously planned, successful and on-going wind energy projects in ASEAN countries and select a site for micro-siting in Malaysia.

2. WIND ENERGY POTENTIAL AND WIND ENERGY UTILIZATION IN ASEAN COUNTRIES

Brunei has small potential to use the wind to generate energy with **annual average of 5 m/s and 7 m/s for offshore wind. There are a potential number of areas that can be suitable locations for wind turbines such as at** the southern side of Brunei which has elevated ridges, some isolated spots in Temburong, areas near the Champion oilfield northeast of Seria, and some far south of Tutong. [1]

The southern part of the great lake TonleSap in Cambodia, the mountainous districts in the southwest and the coastal regions, such as Sihanoukville, Kampot,Kepand KohKong have the annual average wind speed of 5m/s or greater. The introduction of wind power generation system in these areas is promising. [2] On January 2010, the first Wind Power Electricity Generator was inaugurated at Sihanoukville, Cambodia. [3]

The potential of wind energy in Indonesia is relatively low with average of wind speed of 3-6 m/s. However, in certain areas in the Eastern Regions of Indonesia, wind velocity is more than 5 m/s. [4] Indonesia started with a trial project of wind conversion energy system (WCES) TOCARDO in Bantul, Yogyakarta. [5] By the end of 2005, small scale wind energy 1x80kW was acknowledged as first grid in Indonesia. Right after that, Indonesia's first WCES project was initiated in Jepara, Central Java [5]. As of November 2008, a new wind map survey, based on satellite imagery for the whole of Indonesia has been commissioned. [6] Recently, Indonesian Energy and Mineral Resources Ministry had approved a project in Mar 2011 to build the country's first large-scale wind power plant in Sukabumi, West Java, with a total capacity of 30 MW. **Global Wind Energy Council, Indonesia stated that Indonesia wants to build 255 MW of wind turbines capacity by 2025. [7]**

The potential for wind power in Laos is limited but does exist in specific areas of the country. There are currently no wind power systems in Laos. World Bank survey has identified south-central Laos is suitable for village-scale wind power generation. [8]

New Energy and Industrial Technology Development Organization (NEDO) of Japan performed a study in 1997 on renewable energy potential in GMS region and assessed that Myanmar has potentially available Wind Energy of 360.1 TWh per year. Some potential areas such as coastal, islands, wind corridor inland and high plateau areas are identified by JICA/NGO joint survey in 2001. [9] To date, available data on wind energy sources are not enough to evaluate suitable sites for construction of wind turbines thus it is only on R&D phase in Myanmar.

A study by the US National Renewable Energy Laboratory (US NREL) shows that there are 10,000 sq. km. of land areas with good-to-excellent wind resources in Philippines, particularly in the Ilocos region. They have the largest wind power project in Southeast Asia, comprising 15 towers with an installed capacity of 1.65MW wind turbine generator per tower (24.75 MW wind farm) in Bangui Bay, Bangui, Ilocos Norte province. [10] New wind sites offered for developments are 10 wind sites in Luzon, seven in the Visayas and one in Mindanao. Recently, three companies were awarded with pre-commercial contract (PCC) to harness the country's wind energy. They are now conducting actual wind assessment under their respective work programs. [11]

Singapore's wind speed is less than 5 m/s. A wind measurement stations have been installed atop Housing and Development Board (HDB) blocks since June 2011, as part of a study to measure wind speed and direction across the island. The findings will allow the Energy Research Institute, Nanyang Technological University to install 250 to 500 kW wind turbine in the Southern Islands or Semakau landfill. It will also start test-bedding in six months' time a few prototypes of its own urban wind and marine turbines for low wind and low marine conditions. [12]

There are certain areas in Thailand which fit the criteria for commercial wind projects having an average wind speed of 6.0 m/s or above, having good infrastructure and good land accessibility. Thailand has installed a 1.65MW advance wind turbine at Sating Phra. [13] A 2.5 MW Lam Thakong Wind Turbine Power System which is build at Propinsi Nakhon Ratchasima is currently their biggest project in wind energy. [14] The Royal Thai Government is also installing some 44 measurement masts at a height of 60 meters throughout the country to give a better understanding of the wind potential. There are at least 7 to 8 projects in the feasibility planning stages all of an expected capacity of over 30 MW each location with one or two hoping for 100MW installed capacity. [15]

According to the World Bank (2001), the potential of wind energy in Vietnam was estimated about 513,360 MW with 8.6% of the total land area of Vietnam to have the potential for the development of large wind energy turbine (wind speed 7m/s). The most promising areas are located in coastal and highland areas in the south-center and southern parts of Vietnam. Wind power projects in Vietnam include the hybrid 2-30kW wind turbines – diesel generators, the family-scale 150-200kW wind turbines installed mainly in off-grid areas such as islands, and the industrial scale wind power stations. [16] A

project that has been put into the national grid is in Binh Thuan Province. 20 wind turbines of Vietnam Renewable Energy Joint Stock Company (REVN) have been completely installed and connected to the national grid system in March 2011. [16] Currently, there are 42 wind power projects ranging from 6 MW to 150 MW at different development stage. [15]

The development in wind power however has captured only a small part of the ASEAN country's potential. More efforts should be made to fully utilize the wind energy potential in South East Asia.

3. WIND ENERGY POTENTIAL IN MALAYSIA

3.1 Previous wind energy potential studies

Malaysia is located in the equatorial zone and the climate is governed by the NE and SW monsoon which blow alternately during the course of the year. The NE monsoon blow from approximately October until March, while the SW monsoon blow from May until September. [17] Due to the country's location, winds over the area are generally light. At present, there have been few studies related to the wind energy potential of Malaysia.

In the paper by Sopian et al. [18]; it discussed about the result of a study based on a collected wind data from ten stations distributed all over Malaysia for a 10- year period (1982–1991), with all the stations located either at airport, near open sea, flat area or meteorology department. The station located at Mersing (seaside) has the greatest potential with a mean power density of 85.61 W/m2 at 10 m above sea level

Besides that, a case study of the wind energy potential at Pulau Perhentian (Perhentian Island) has also been carried out by Darus ZM et al. [19]. They published a study which encompass on the hybrid system implemented at the Perhentian Island, Malaysia. Pulau Perhentian is one of the popular resort islands in Malaysia which consists of a cluster of islands off the East (E) coast of Malaysia which is about 21 km from the coast of Terengganu. In the study, a hybrid system integrated with a wind turbine and solar panel had been installed so as to minimize the use of diesel as a source of electricity in Pulau Perhentian .

E.P. Chiang et al. [22] have presented their paper studies on the *Potential of Renewable Wave and Offshore Wind Energy Sources in Malaysia*. Malaysia is a country vastly surrounded by water. Analysis was conducted for the potential of wave energy and wind energy along the coastline of Malaysia from the data obtained by the Malaysia Meteorological Service (MMS) from 1985 to 2000. Locations situated in the South China Sea has the most promising site for wave power potential, with the highest energy resource available in the months of November to February, which coincide with northeast monsoon season. The offshore wind energy resource for this region also shows the same trend as the wave energy. The highest potential is in the east peninsular Malaysia with annual vector resultant wind speed of 4.1 m/s. [22]

While T.H Oh et al. reported that a 150 kW wind turbine in Terumbu Layang Layang was demonstrated with some success by a team from Universiti Kebangsaan Malaysia (UKM). [23]

In addition, the research of Zaharim et al. has summarized that the numerical and graphical results obtained from the Weibull and Gamma distributions, which parameters are estimated using the maximum likelihood principle, provide the best fits for the wind data. The wind speed data were obtained from Universiti Malaysia Terengganu (UMT) which is located in the east coast of Malaysia. Measured over two years period of time, the probability distributions derived from the wind speed data and their distributional parameters are identified. [24]

I. Daut et al. [25] discussed about the potential of wind speed for wind power generation in Perlis, northern of Malaysia based on the wind sped characteristics for the year 2006. The Weibull distribution function is applied to analyze the wind speed characteristics and used to calculate the wind power generation potential. Potential of wind power generation is observed and analyzed during 24 hours (9th March 2011). The analysis result of monthly mean wind power and energy density show that the early (January to march) and the end (December) of year have a high wind power and energy potential, but the middle of year they are very low, it is necessary to develop a special wind power generation capable of harnessing the little wind resource available in Perlis.

Recent study by T.L Tiang et al. [26] had assessed the wind potential in Bayan Lepas, Penang Island by using real-time wind data. Within the investigation, the wind-speed, the prevailing direction, the duration and the diurnal variation were assessed. Based on the investigation, the results show that the measurement site falls under Class 1 of the International System Wind Classification. The results of this investigation also indicate that the grid-network connected to the wind turbine-generator systems may not be a commercially viable proposal in Penang. Nevertheless, a small-scale wind turbine system is more suitable and sustainable in Penang Island. [25]

3.2 Present wind energy utilization in Malaysia

A 150 kW wind turbine in Terumbu Layang Layang was demonstrated with some success in the year 2005. [23]

Then, Malaysia National Electric Board (TNB) has embarked a project of integrating power supply at Pulau Perhentian in 2007. The project consists of installing two wind turbine and solar panel. Both wind turbine (WT 1 and WT 2) produce 18 KW each. Meanwhile the solar PV produces 39 KW. Total energy produce by RE farm is 75 KW. However this hybrid integrated RE has stopped working in the year 2010. [19]

Considering the fact that mean wind speed in Malaysia is around 2-3m/s; iWind (M) Sdn Bhd brings in the Vertical Axis Wind Turbine (VAWT) technology from Taiwan into Malaysia. The main advantage for using vertical axis wind turbine is it can produce

energy at lower wind speeds, as slow turning vertical axis turbine can run efficiently at 2.5 - 9 m/s which are ideal for relatively low wind in Malaysia.

Figure 1: iWIND Vertical Axis Wind Turbine on the roof top of GreenTech Malaysia

To date, iWind Energy (M) Sdn Bhd has installed 40 of its iWind Vertical Axis Wind Turbine (VAWT) in Malaysia.

3.3 Wind resources assessment in Malaysia

The meteorological data used in this study are gathered from fourteen stations located at Alor Setar, Bayan Lepas, Ipoh, Kota Bharu, Kota Kinabalu, Kuala Terengganu, Kuantan, Kuching, Labuan, Malacca, Mersing, Miri, Senai and Subang. The data for this study consists of hourly wind records over the 3 years period starting from 1st Jan 2007 until 31st December 2009. This data are taken from Malaysian Meteorological Department, Petaling Jaya which consist of wind directions and wind speeds measured at height of wind sensor at 10m.

3.3.1 The Wind Speed Distribution

The highest mean monthly wind speed for Malaysia in overall is recorded at Mersing throughout the 3 years (2007-2009) observations period. The mean wind speed distribution is graphically represented in the figure 2 and figure 3.

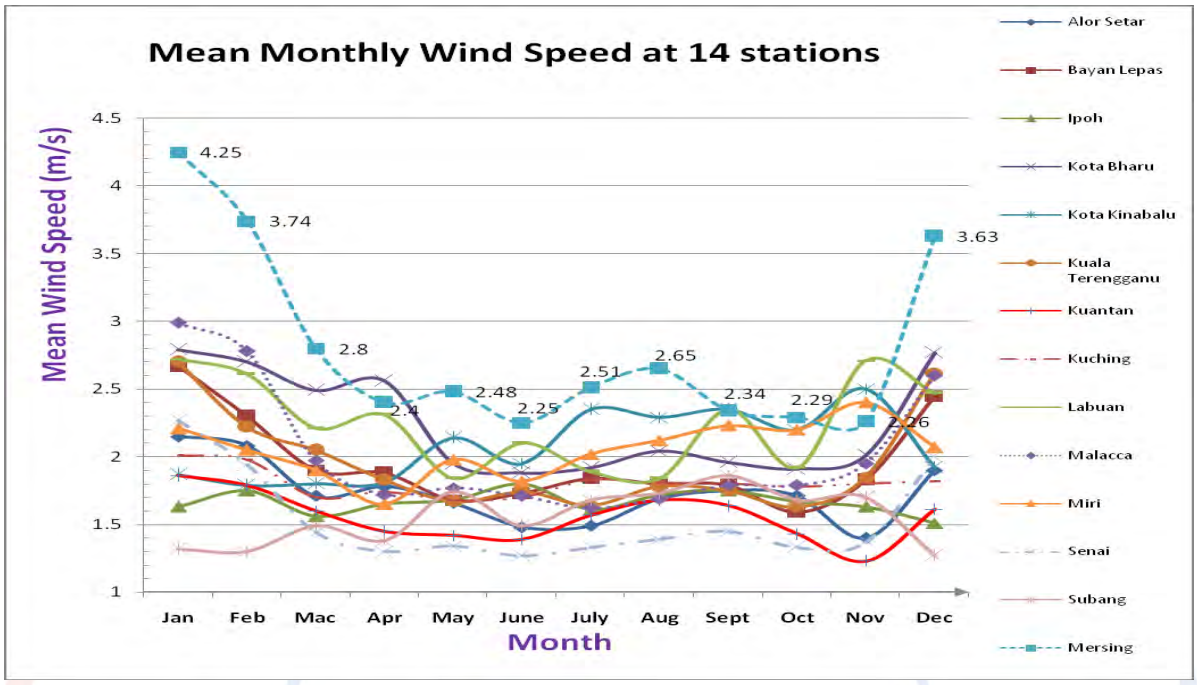

Figure 2: Mean Monthly Wind Speed for 14 stations all over Malaysia

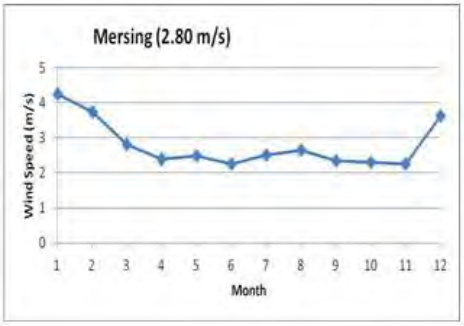

Figure 3: Annual Mean Wind Speed for Mersing (2007-2009)

Basically the most potential location of installing wind turbine generator in Malaysia can best be selected according to the place which offers highest and constant value of mean wind speed for the three consecutive years. One more factor in selecting the potential location of installing wind turbine generator is by considering the place which records the highest wind speed amongst all the 14 stations.

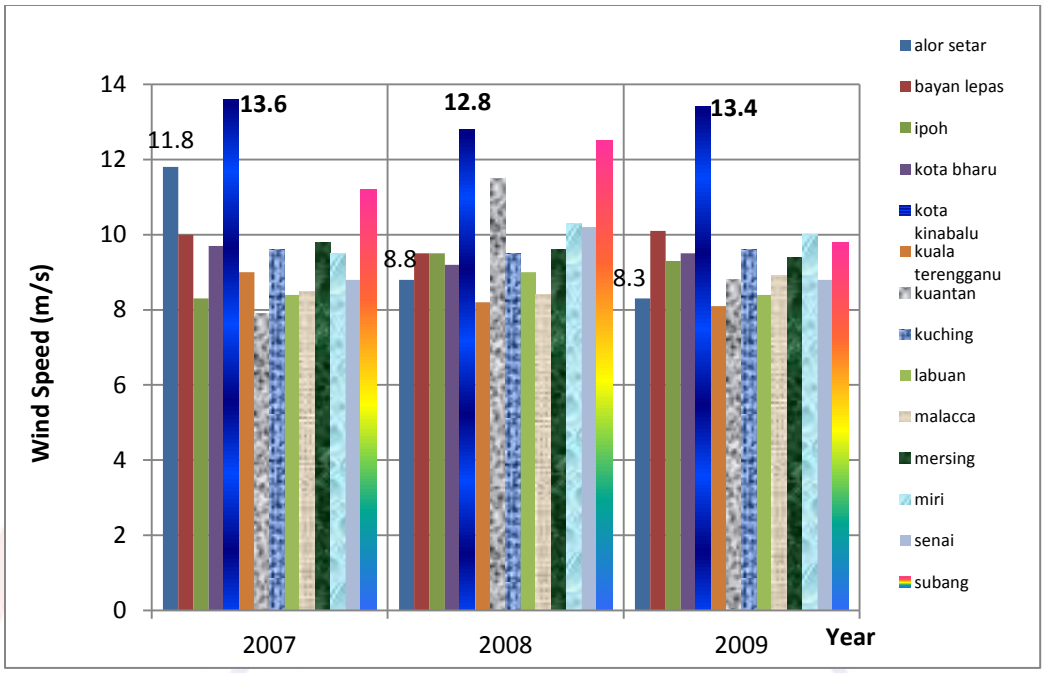

Figure 4: Maximum wind speed recorded at fourteen stations in Malaysia for 2007-2009

The highest value of wind gust was recorded at Kota Kinabalu as depicted in the Figure 4. The highest value of wind speed in 2007 was recorded at Kota Kinabalu (13.6 m/s). The value was recorded at the end of October 2007; which indicates the starting of the Northeast Monsoon season. Whereas in the year 2008, Kota Kinabalu (12.8 m/s) has again marks the highest value of wind speed and it was recorded at the end of September 2008; which is during the last month for the Southwest Monsoon season. While for the year 2009, Kota Kinabalu (13.4 m/s) shows the highest value of wind speed followed by Miri (10.0 m/s). Both values were recorded on October 2009.

It can best be described that maximum wind speed usually occurs at the end of the Southwest Monsoon season as shown in Figure 5.

Figure 5: Max wind gust for Kota Kinabalu (2007-2009)

3.3.2: Mersing as potential location

Mersing is considered as one of the potential site for Malaysia based on the value of highest mean wind speed (figure 1, 2) compared to 13 other stations. The mean surface winds over peninsular Malaysia are generally mild, with the mean speed of about 2.3 m/s, and a maximum speed of less than 14 m/s. The main direction is variable. Further studies should be carried out at Mersing to locate the best point that can trigger the highest wind energy power.

The monsoon season in Malaysia can be divided into southwest monsoons (SW) from Mei to September and northeast monsoons (NE) from November to Mac season whereas the months of April and October are known as the transition periods (TP) between the two monsoons. The direction of the wind is from the northeast and east quadrant during the northeast monsoon season and south and southwest quadrant during the southwest monsoon season as depicted in Figure 8. The Northeast monsoon season plays in important role as this monsoon season usually imply high value of mean wind speed as shown in Figure 9.

Figure 6 shows that the monthly mean wind speed at Mersing is higher during the NE monsoon season from Nov-Mac 2007 – 2009. The mean wind speed during the NE monsoon ranging from 2-5 m/s. Note that the lowest value of mean wind speed are recorded during the transition period (Apr & Oct). Whereas, mean wind speed is low and almost constant during the SW monsoon season ranging around 2-3 m/s.

Wind is caused when air moves from an area of high pressure to one of low pressure. The greater the difference between those areas, the stronger will be the wind. The hourly speeds are high during the day, and the calm periods will mostly occur at night. The situation can best be expressed based on figure 7; that during the day, the sun heats the air, which in turn becomes more active as differently heated parcels of air rise, fall and move about in relation to each other, in a never ending effort to establish an even state. This is why it is generally windier in daytime compared to night-time.

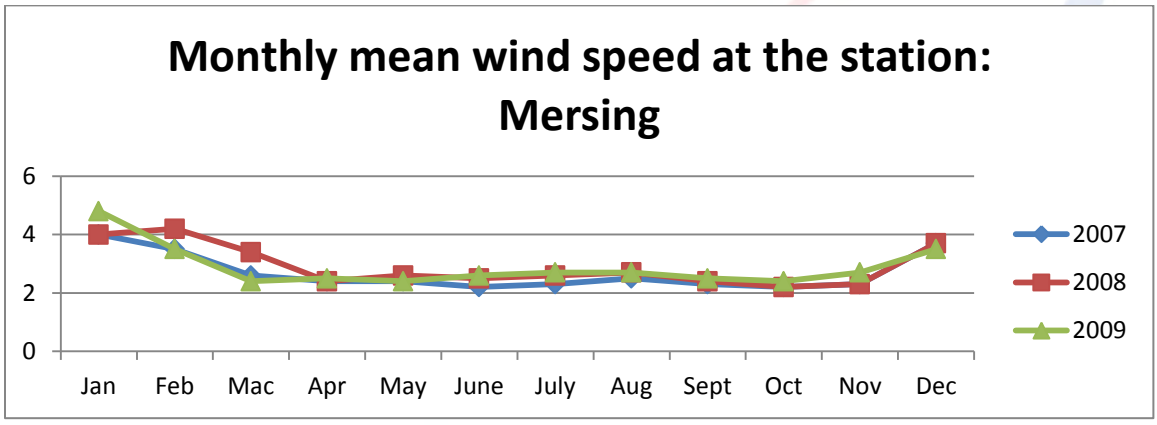

Figure 6: Monthly mean wind speed at Mersing for the year 2007 to 2009

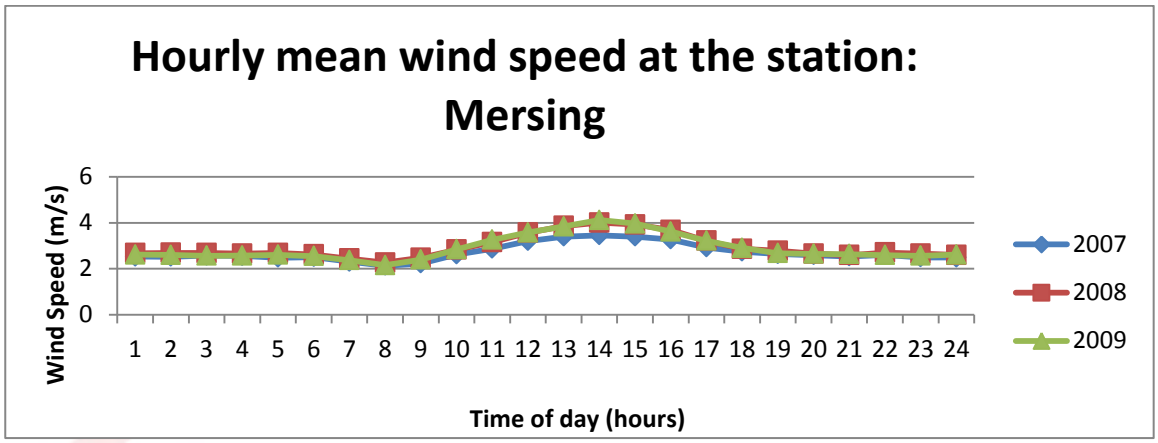

Figure 7 : Hourly mean wind speed distribution at Mersing for the year 2007-2009

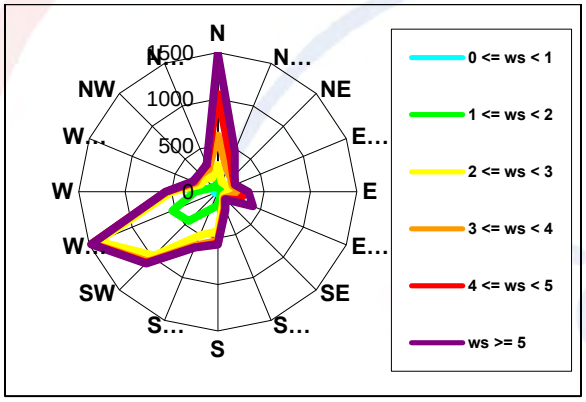

Figure 8: Wind rose at Mersing (2009)

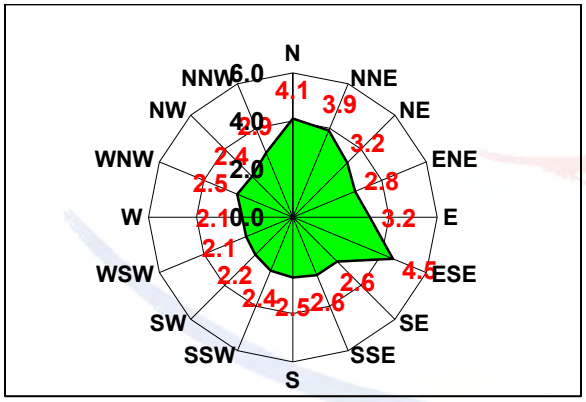

Figure 9: Average speed according to the wind direction at Mersing (2009).

The frequency of occurrence is highest for wind speed 2-3 m/s followed by wind speed of 1-2 m/s as shown in Figure 10.

Frequency percentage for different hub height is calculated and the result is shown in Figure 10. For wind speed 1-2 m/s and 2-3m/s; the most optimum hub height is at 10m. Whereas for wind speed of 3-4m/s and 4-5m/s; the most optimum hub height is at 25m.

Considering the frequency of occurrence (figure 10) and frequency percentage (figure 11), it is best to suggest that Mersing use hub height of 10 – 25m for its wind turbine tower.

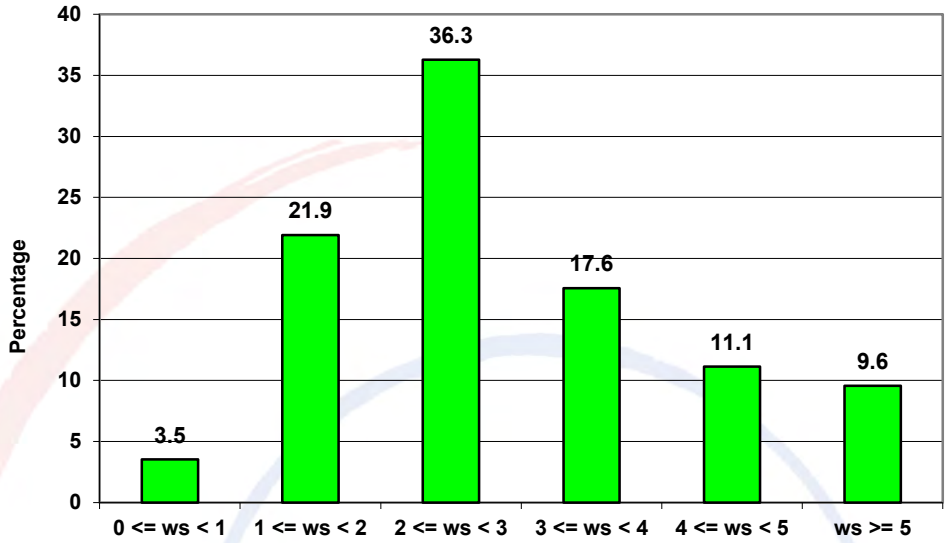

Figure 10: Distribution of wind speed class at Mersing (2009)

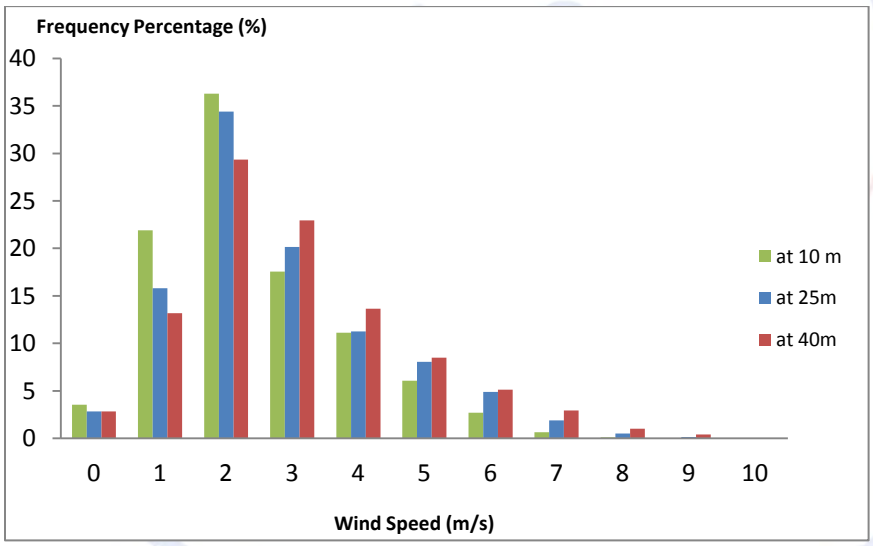

Figure 11: Frequency percentage for hub height 10m, 25m and 40m at Mersing (2009)

4.0 MICRO-SITING IN MERSING USING RIAM-COMPACT SOFTWARE

4.1 RIAM-COMPACT Software

As meteorological wind data alone is not sufficient for accurate siting of a large wind power project, a numerical model called the RIAM-COMPACT (Research Institute for

Applied Mechanics, Kyushu University, Computational Prediction of Airflow over Complex Terrain) is perfect for micro siting process of evaluating the exact potential location to install wind turbine generator (WTG).

By using this software, wind simulation of an actual wind farm was executed using the high resolution elevation data. The RIAM-COMPACT® CFD model is based on Large-Eddy Simulation (LES) technique. The computational domain of RIAM-COMPACT® can extend from several meters to several kilometers, and RIAM-COMPACT® can predict airflow and gas diffusion over complex terrains with high accuracy. [27] As a result, an appropriate point and an inappropriate point for locating WTGs were shown based on the numerical results obtained. This cause was found to be a topographical irregularity in front of WTGs.

4.2 Micro-siting in Mersing

Mersing is a town in the northeast corner of the state of Johor, Malaysia. Mersing lies on the main road that connects southern as well as eastern Johor with the east coast of Pahang and it is the main departure point for ferries to the nearby offshore islands such as Pulau Tioman.

Micro-siting technique is important to locate the exact point for the optimum performance of the individual wind turbine in the wind farm. Recently, it has been reported that the utilization rates of WTGs on wind farms situated on complex terrain fall short of expectations; that is, reports of damage and breakage of the exteriors and interiors of WTGs as well as WTGs with notably low power output have surfaced. Terrain-induced turbulence is considered as the major cause of these issues [28]. The source of terrain-induced turbulence is small variations in the topographical relief in the vicinity of WTGs at which turbulence is mechanically generated. [29] The simulation results produced by RIAM-COMPACT Software can suggest which wind turbine in the wind farm are affected by the wind risks (terrain-induced turbulence).

4.2.1 Simulation set up

In this study, a wind synopsis analysis is performed from Kampung Penyabong Pantai to Sungai Sisek in Mersing.

Figure 12: Selected area in Mersing

The number of grid points is 50 x 50 x 40 points (approximately 100000 points). The calculation domain is 10000m x 10000m.

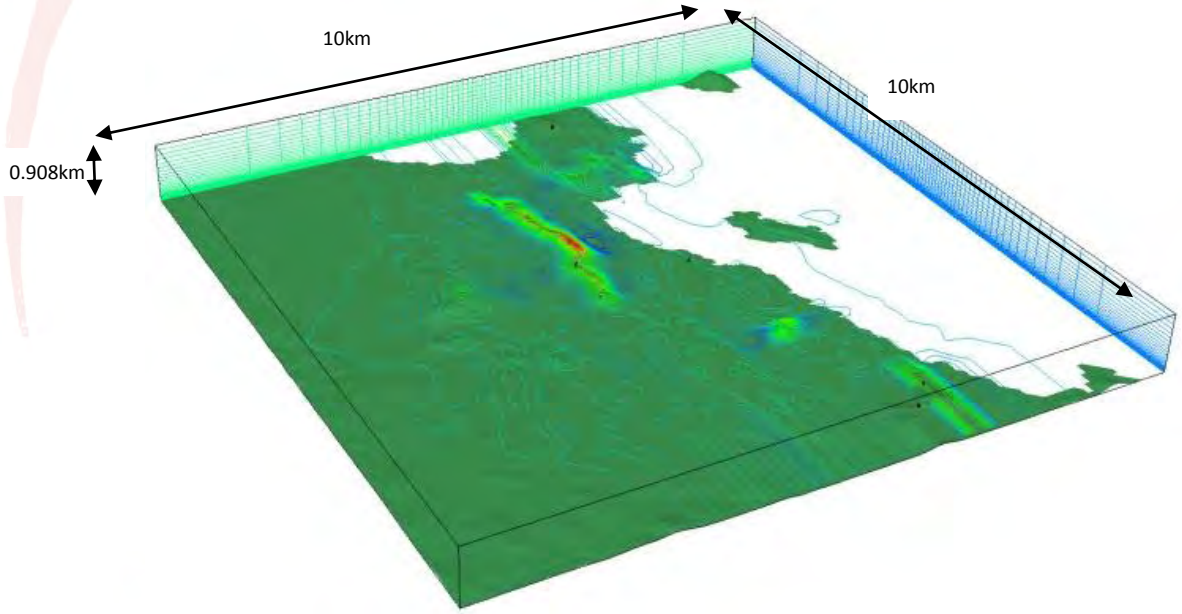

Figure 13(a): Bird's eye view

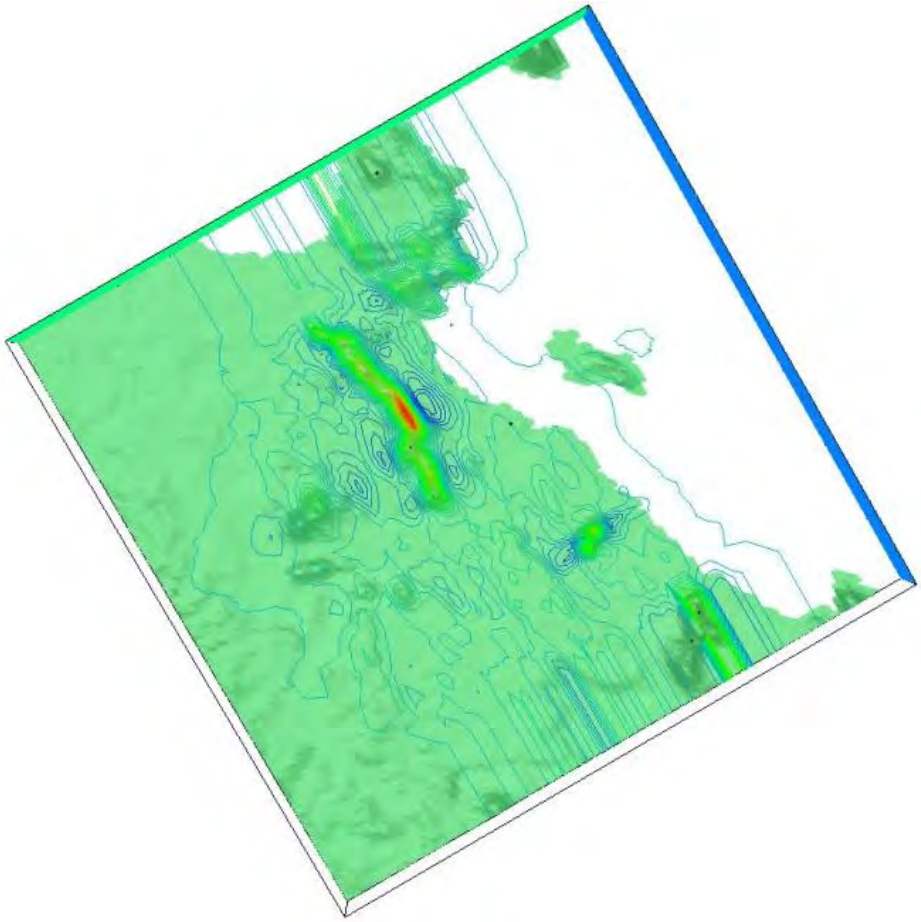

Figure 13(b): Top view

Figure 13(c): Position of wind turbines

The high resolution elevation data were constructed using Geographical Information System (GIS). The wind directions considered for the simulation is west-south-westerly as according to the prevailing wind direction as discussed in 3.3.2 (figure 8). In the RIAM-COMPACT, if the diameter of the rotor, the height of the hub, and the display color, etc. are set, and the location is specified, the 3D line chart of the Wind Turbine Generator (WTG) can be inserted into the calculation result. [28] The WTG in this study has a rotor diameter of 30m, and a hub height of 35m. The boundary conditions for the velocity field in the computational domain are as follows: 1/7 power law profile (inflow), free slip condition (top and side boundary), convective outflow condition (outflow), non-slip condition (ground).

4.2.2 Simulation Results and Discussion

Although 10 WTG are set for simulations, we only discussed for WTG3 and WTG4 because of space limitations.

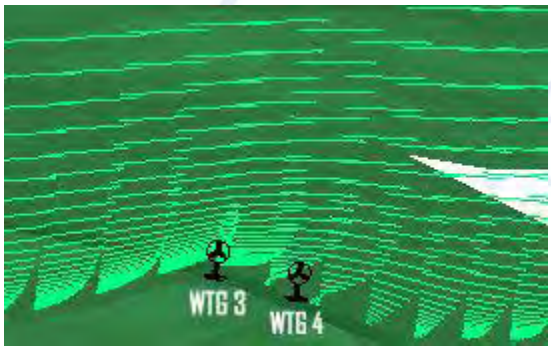

Figure 14(a): velocity vectors of WTG3 and WTG4

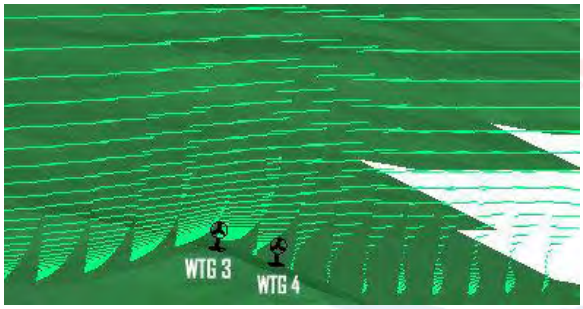

Figure 14(b): velocity vectors of WTG3 and WTG4

The wind velocity vectors along vertical cross-sections for WTG 3 and WTG 4 suggest that the two WTGs in Figure 14 are subject to significant influence from separated flow (terrain induced turbulence) which is generated upwind of the WTGs.

In the case of WTG 3, it is understood that all rotor heights share almost the same speed distribution. In addition, a local speed-up due to geographical effect is confirmed. The separated flow is confirmed under the rotor center in the case of WTG 4. This is due to the turbulent flow generated from the topographical irregularity in front of WTG 4. That is, WTG 4 is influenced by the turbulent flow generated by geographical features as this tower is located in a lower point that shifts slightly from the hilltop.

The wind velocity vectors at the WTG 4 illustrates that large velocity deficits are present at multiple heights, which shows there exist large differences in the wind velocities between the lower and upper ends of the area swept by the blades. The unexpected large differences in the wind velocity across heights may induce vibrations of the WTG 4 and may also cause internal damage and breakage of the WTG 4.

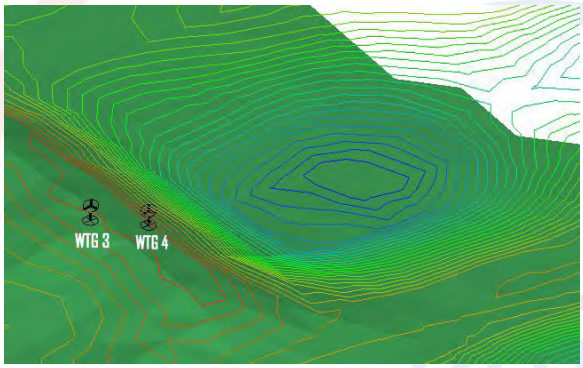

Figure 15(a): contour lines of turbulence intensities

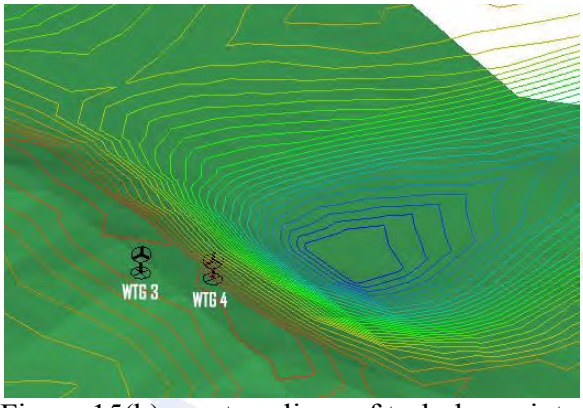

Figure 15(b): contour lines of turbulence intensities

In Figure 15, the fluctuating velocity is small at WTG3 compared t WTG4. It should be noted that the distribution of contour lines changed with time. At some time, the blue area shows that separation appeeras at the area; which also means that it is not a good idea to locate a WTG. As WTG4 is closed to the separation area, it is not a good location to place a turbine there.

5.0 CONCLUSION

RE in ASEAN while abundant is seriously underdeveloped due to a lack of technology and funding. Wind energy is emission-free during operations, has few environmental concerns, and can be easily integrated into the electricity grid. Modern wind generating equipment is efficient, highly reliable, and becoming cheaper to purchase.

The most potential countries for wind energy in the Southeast Asia region are Philippines and followed by Thailand. While the most progress in wind energy utilization are Philippines and followed by Thailand, Malaysia and Vietnam. Efforts are being made to introduce wind energy in some country like Laos and Myanmar, but so far it is not enough to fulfill the energy requirements of the rural communities; and many efforts must be done in terms of research and implementations.

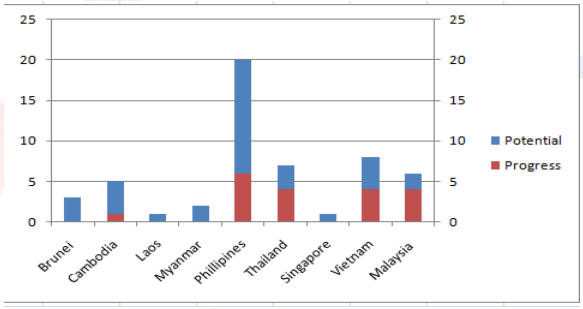

Figure 16: The potential and progress of wind energy in ASEAN

The main idea to bear in mind is ASEAN countries has to perform deliberate and thoughtful considerations on positioning the wind turbine to best capture the wind to ensure the profitable productivity. The cost efficiency can be critically reduced if the production of the energy is too distant from the demand center.

Overall, it can be concludes that the implementation of wind energy conversion in Malaysia can be a reality if there are enough funding and supports from government and industry. Hopefully Malaysia will be standing in the eyes of the world as one of the country that can yield renewable energy by fully utilizing its wind energy sources in the near future.

Also, i**n order to obtain the high wind velocity offshore, it is suggested that ASEAN countries introduced 'Wind Farm on the Sea' which consists of wind turbines planted uniformly on platforms above sea level and transmits the energy through cables connected to the main generator or station on land.** [1] **For example,** Singapore has limited land; so the turbine can be put in the sea and double up as a tourist attraction. [19]

A numerical simulation for the wind farm Mersing was executed to locate the appropriate and inappropriate points for locating WTG. In the discussions, it was shown that a by performing micro-siting, we can predict the wind risk (terrain induced turbulence) at the selected wind farm. By applying this micro-siting technique, the damage and breakage of the WTGs as well as WTGs with notably low power output caused by the terrain induced turbulence can be avoided.

Cheap, easy to maintain, clean and renewable energy must be researched carefully to fix these problems as power is also important for the people in South East Asia to progress and increase their living standards.

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Disaster Mapping and Assessment of City of Kamaishi's Coast Affected by The Great East Japan Earthquake

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The Asian Conference on Sustainability, Energy and the Environment

Official Conference Proceedings 2012

Abstract:

The present study aims at assessing the immediate changes to the coastal natural and man-made environment in the aftermath of the Great East Japan Earthquake and tsunami that hit the City of Kamaishi of Iwate prefecture on 11 March, 2011. The city is endowed with a rugged mountainous terrain and economy heavily invested in eco-tourism and fishing activities. It also has to its credit, the world's deepest breakwater constructed at its harbour and which in fact offered little or no resistance to the tsunami in preventing the coastal city from being submerged.

The methodology adopted includes use of high resolution satellite images acquired before and after the disaster and OpenStreetMap in creating damage assessment maps. And with government set to revive reconstruction of deep breakwater and with already $1.6 billion invested, it is more pertinent to assess if the existing wall had been any effective so far. Results of the study through thematic coverage of the damage offer insight into environmental impact on the Kamaishi city's coast.

Key words - Tsunami, breakwater, spatial analysis and disaster mapping.

Introduction

The tsunami that hit the coast of Iwate Prefecture soon after the earthquake on March 11, 2001 caused substantial human and physical destruction in the coastal city of Kamaishi. The city with the protection of breakwater was supposed to be safe, prepared and less vulnerable specifically to a natural calamity that struck the shore.

The breakwaters at the bay mouth of Kamaishi (Fig. 1.0), considered the world's deepest, consists of North breakwater of 990 m long and South breakwater of 670 m long with a central opening of 300 m wide in the middle (Murata *et al*. 2010). Constructed at a water depth of 10 to 63 meters, it has almost 70% of the total length located at water depth deeper than 50 m. (Tanimato *et al.* 1992). The construction work of breakwater started in 1978 and was finally completed in March 2009 at a cost of $1.5 billion (Onishi, 2011).

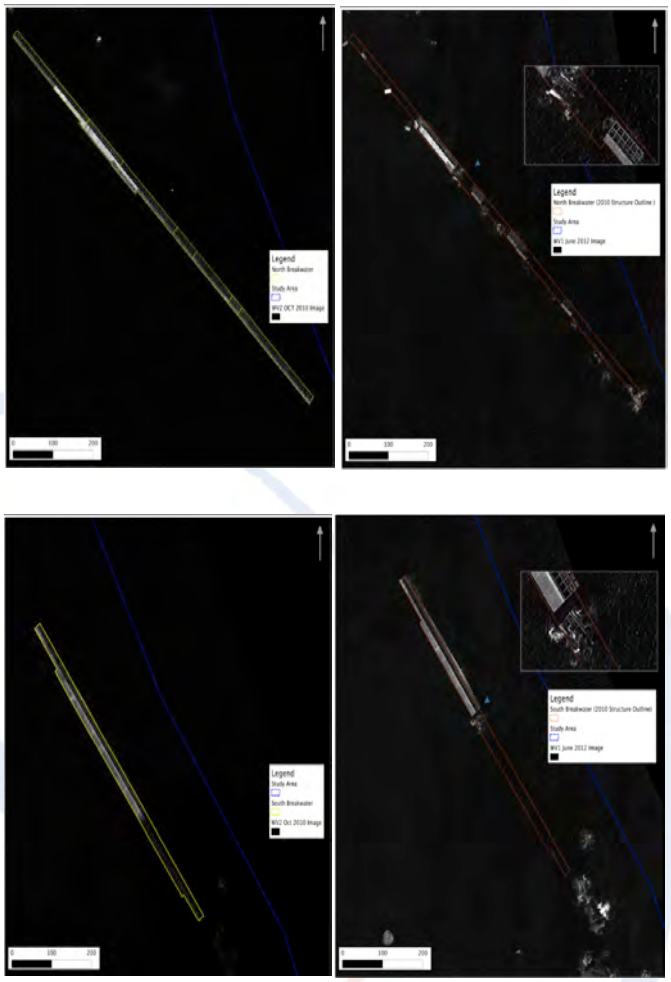

Fig.1.0 Pre and Post Tsunami Image of Breakwater

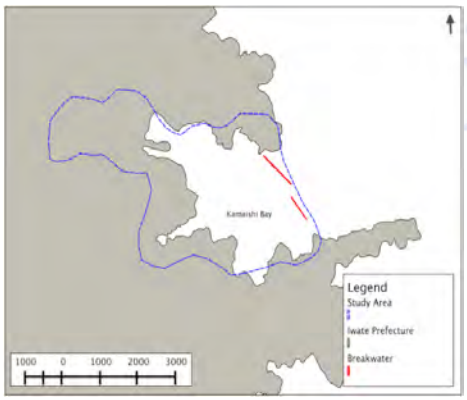

Fig.2.0 Pre and Post Tsunami Image of Breakwater

Reduction of Tsunami height by means of offshore breakwaters was considered as a solution for protection of the port area from tsunamis as well as storm waves. Tsunami breakwaters are designed to restrict the inflow of tsunami waves into a harbour by narrowing the bay-mouth entrance to decrease tsunami run-up height as well as wind waves and swells. As per findings of the Iwate Prefecture Disaster Countermeasures Headquarters, a total of 879 people died and 349 people remained missing (as of July 25, 2011) in Kamaishi. Damage to fishing industry and fishing ports was noted to be in the range of ¥358.7 billion followed by industrial or manufacturing damage amounting to ¥ 89 billion. With respect to public works, the damage to river coastal facilities and road infrastructure was estimated to be ¥172.3 billion. It was also noted that a total of 29,544 homes were damaged of which 24,534 were either fully or partially destroyed, mostly attributed to tsunami. The report noted that 88,000 people lived in regions where water reached, which is approximately 30% of the affected population.

The Basic Reconstruction Plan that's drawn by the Iwate prefecture government office on April 11, 2011 laid emphasis, as part of the maintenance of coastal protection facilities, to study the mechanism of destruction to the coastal protection facilities as a result of this tsunami. The structures covering entrance breakwaters, coastal levees, river embankments, floodgates, and land locks, were highlighted as those to be reviewed alongside community planning during restoration and maintenance work. Currently with the government planning to revive the reconstruction of the

breakwater (Onishi, 2011) and with the official pointing out the structure as being 'the most efficient and cost-effective choice,' greater assessment can be called for.

The current study aims to ascertain the extent of damage using combination of high-resolution optical satellite images complemented by ancillary OpenStreetMap data for a small sample area of 17 Sq. Kms. encompassing the region from the breakwater to the coastal vicinity. It seeks to understand the spatial extent of damage at a local scale that the policy framework would need to address.

Image and Ancillary Data Selection

For the study, a combination of high-resolution optical satellite image, data from OpenStreetMap and Aster GDEM were used. The satellite images assisted in the damage interpretation as it provides a visually picture of the structural damage from above. The images also enabled to comprehend areas that are critically affected. The area of interest for the study covers 17 Sq. Kms. encompassing the breakwater to the coastal vicinity Kamaishi city. This covers a broad stretch of land-use pattern covering residential, commercial to industrial use.

For satellite images, DigitalGlobe's WorldView1 PAN Image acquired on June 4, 2011 and WorldView 2 PAN image acquired on Oct. 06, 2010 at 0.5 m resolution were selected. At this resolution, the imagery is invaluable in mapping of urban areas in high detail. The OpenStreetMap has features covering building footprints, highways, administrative boundaries, local landmarks to

Fig.3.1 WorldView 2 PAN image acquired on Oct. 06, 2010*(Pre Tsunami Image)* © 2012 DIGITALGLOBE, INC

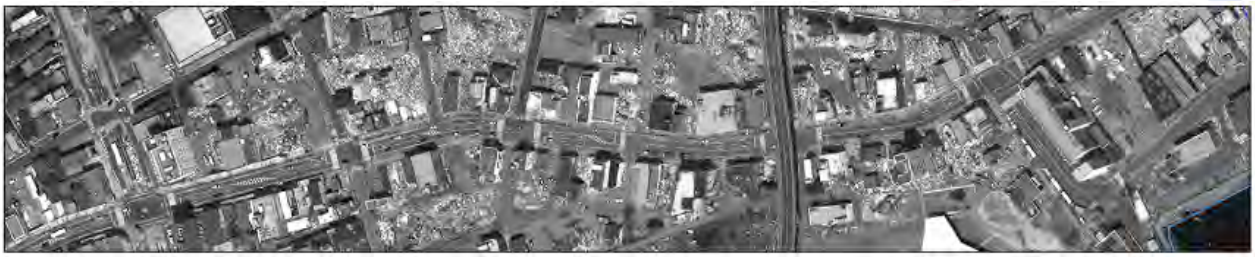

Fig.3.2 WorldView1 PAN Image acquired on June 4, 2011 *(Post Tsunami Image)* © 2012 DIGITALGLOBE, INC

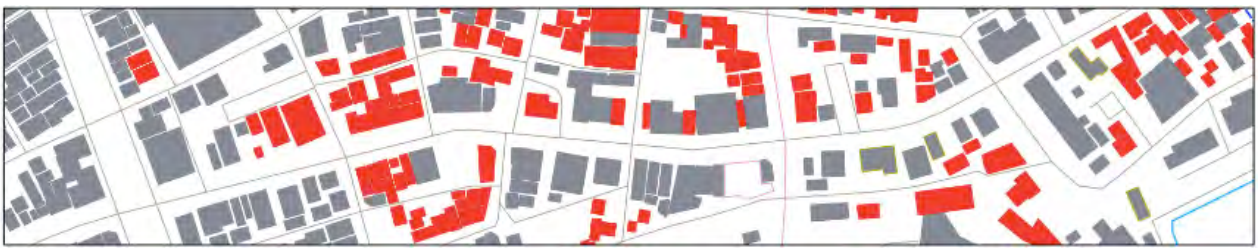

Fig.3.3 Classified Disaster Map (red shown as 'damaged' and 'grey' those that are still standing.

land-use. The database is built by contributors using Global position System receivers to create set of points and lines, that is then turned into maps. To understand the local topography and extend of buildings that are in the low lying area that's vulnerable, ASTER Global Digital Elevation Model (ASTER GDEM) at 30 resolution was used. As part of the data preparation, an image-to- image co-registration and setting to a common projection was carried out to reduce any horizontal

discrepancy between the data.

Methods and Results

Damage detection using a unique manual approach was employed in producing a quick and effective overview of damage extent of structures in the coastal areas. Though a detailed damage assessment can only be produced long after rigorous processing of remote sensing data in combination with field survey of a number of variables, for the current study, the current assessment is mainly limited to the built-up area. A two-stage process was utilized. In first stage the base pre-event Satellite image of Oct. 06, 2010 was compared with the OpenStreetMap data having details of the area prior to the destruction. Then the post-event image June 4, 2011 was employed to extract the damage extent and damage levels. Mapping of intact and destroyed buildings was based primary on visual interpretation of spatial similarities in the pair of images followed by updating the corresponding building status in the OpenStreetMap. This removes the hurdle of any digitization as base data is already available.

The damage feature that can be identified from the satellite image is only structural destruction or major structural failure. This was interpreted from the change in corresponding building or structures shape. For the study, only those building that are seen as collapsed or partially collapsed were classed as 'damaged' and rest as 'standing.' As can be observed in Figure 3.3, the buildings were set to damaged (shown in red) or not (shown in grey) by comparing the corresponding images (Fig. 3.1 & Fig 3.2).

Discussion

The current study made use of visual interpretation of damage for a small representative study area (shown in blue outline in Fig. 1.0) in Kamaishi. From Fig.2.0, shows the Pre and Post Tsunami Image of the North and South breakwaters. Both the structures can be seen as more or less destroyed with only parts or sections of wall still rising from the water. Given the extent of the damage, it does bring out the important question on how much of the structure has survived below water and if repairing it would be any affective than before.

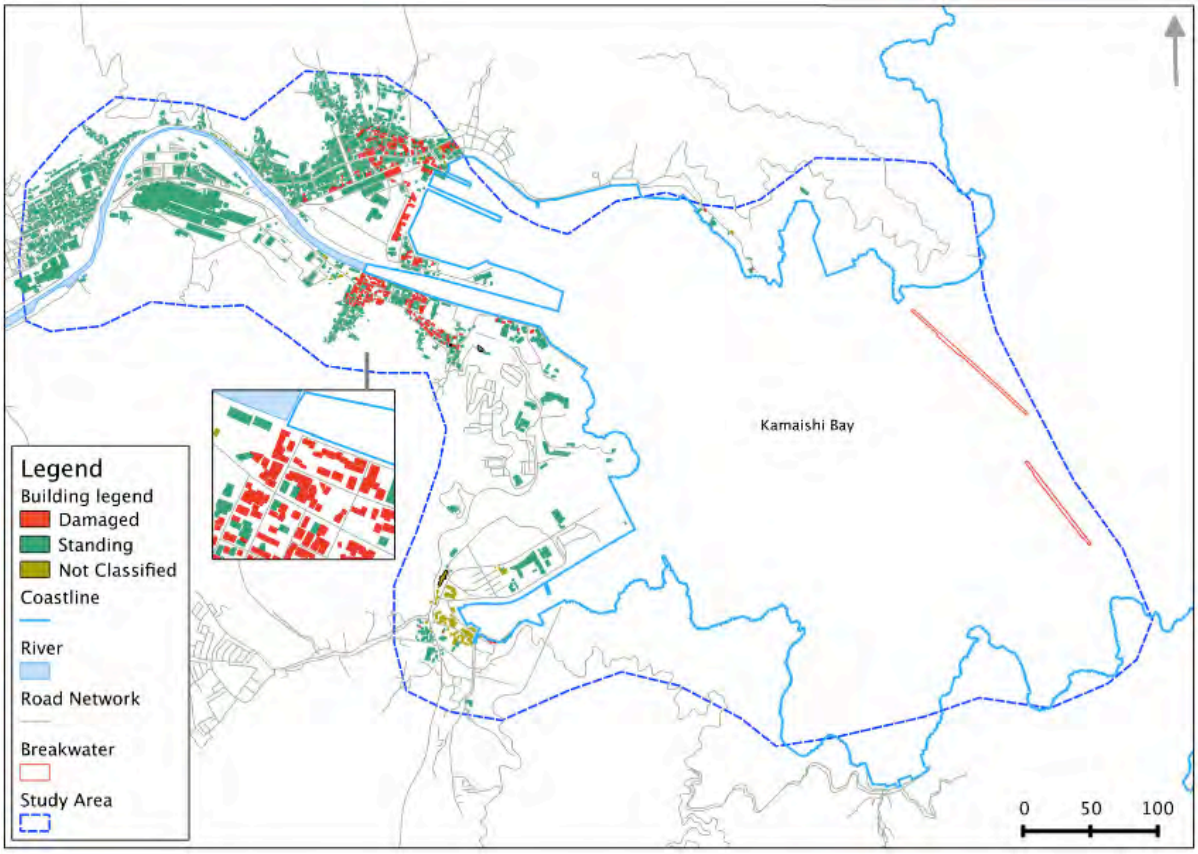

Fig.4.0 Kamaishi Damage Assessment Map

It was noted that settlements are more clustered along flat topography along the river mouth in the bay area. Mountainous and forested terrains lie alongside. With a dense network of roads, highway and rail network, the city can be considered as fully developed in infrastructure when tsunami struck. Buildings were differentiated and mapped as standing, damaged and unclassified. This was then used to compile a final Damage Assessment Map for the Kamaishi (Fig. 4.0).

Most of the damaged buildings and structures were observed near the coast. To have a idea of the topography of the area, contours were created from ASTER DEM (as per Fig. 5.0) and overlaid with the existing buildings. Damage of completely destroyed buildings was noticed more in the region with a ground height of 25 Mts. Given most of the area along the river share similar low ground height, it can be assumed that the tsunami's path would be channelled along this route. This is to be corroborated with debris map and ground structural damage which are not considered in the study.

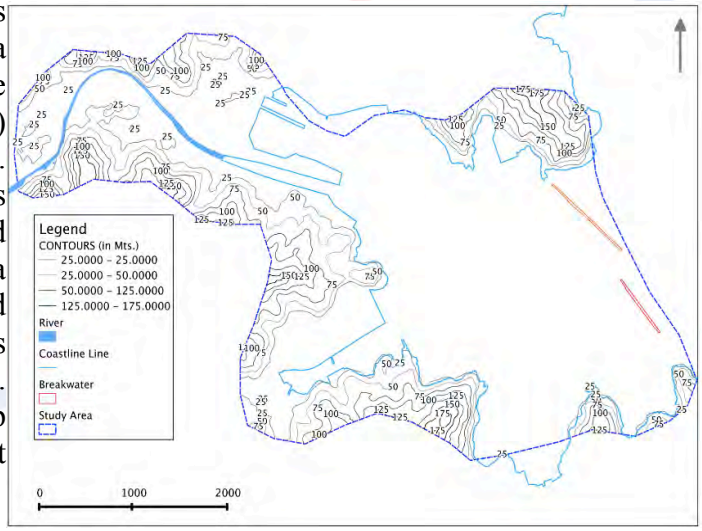

Fig.5.0 Topography with- in the AOI .

Of a total no of 2948 buildings that were mapped in OpenStreetMap, it was observed 524 building as fully damaged. Prominent structures that were destroyed or lying in this vicinity that bore the maximum damage includes town hall, community building, fire-station to bank. Though this is not a comprehensive list, this should give a fair indication with schools, hospital and commercial centres lying within close

proximity. This would call for new city zoning and reconstruction to carefully review the new demarcation areas and also to completely redraw the areas for residential area and possible rehabilitation to higher grounds in a phased manner.

Fishing and Industrial activities being one of the primary mainstay of the economy in the region, the basic reconstruction policy set by Iwate government aims at quick removal of disaster waste (rubble) and objects hindering fishing harbours and fishing grounds, as well as the urgent restoration of coastal protection facilities aimed at fishing industry regeneration. The reconstruction plan also aims at resumption of damaged businesses, promote regional economic activity by creating new industries. The residential areas alongside commercial districts and public interest facility areas are proposed to be planned be built on higher-altitude areas and on mountains away.

One of the major limitations of the current study is that it does not consider a range of variables covering economic, social and demographic nature in disaster assessment. The primary images used in the study were not acquired immediately prior and after the disaster. The assessment that's carried out therefore would not be fully reflective of the ground situation. Further with the buildings and structures interpreted and classified as "standing" might in fact be having significant damage which can only be ascertained from ground survey. Also OpenStreetMap being updated on volunteer basis, thoroughness and accuracy of the data cannot be verified. It should also be noted that the settlements in southern region of the Kamaishi Bay were not considered in the study given the issue of cloud cover in one of the images. This precluded us from making any comparison. It is recommended, for a larger area, automated object-based damage detection be carried using True Colour images and also include variables like structure, shape, size, spectra and texture. Given any major reconstruction plan would lay emphasis on the feedback from the public, the new policies and reconstruction plans should try to endeavour to make damage assessment being available online, through means of PPGIS (Public Participatory GIS) to empower the affected coastal communities to have broader picture and better respond to government's new proposals.

Conclusion

The findings from this study shows that the coastal area of Kamaishi was affected significantly in terms of destruction of buildings and structure in spite the presence of breakwaters. The current study made use of high resolution imagery and open source data of infrastructure in mapping of damage. Most of the sections of the breakwaters were seen to be destroyed. Though mapping was only limited to damaged buildings and structures, it does offer insights into the spatial correspondence of areas of high damage.

With significant level of settlements in low lying area, as part of the policy planning, it becomes essential to review closely if it's better for the communities and industries are to be rehabilitated or if money should still be spent for the reconstruction in these vulnerable areas. For better assessment, the study could be replicated for a larger area considering all tsunamis inundated areas and compare with shores without breakwater while considering the vulnerability of structures, population density, existing land use and the current geotechnical- and structural-engineering constraints.

Acknowledgement

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Open Street Map is made available through www.openstreetmap.org

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Moisture Removal Rate in a Solar Powered Liquid Desiccant Air Conditioning System

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Abstract:

Air conditioning is an energy intensive process, especially in hot and humid climates. Therefore, increased research and development of solar alternatives to conventional space conditioning technique are desirable both in terms of overall cost saving and minimizing the environmental impact. The main disadvantage of vapor-compression air-conditioning systems is that they are inefficient thermodynamically. The handling of the latent load requires cooling of the air below its dew point, and thus additional energy is needed to reheat the air to the delivery temperature. Liquid desiccant air-conditioning systems remove the latent load directly from the air by absorbing the moisture by liquid desiccant solution. The liquid desiccant is then regenerated, again by using low grade heating source like solar energy. In addition to dehumidification, an added benefit of some desiccants is their ability to absorb inorganic and organic contaminants in the air. Moreover, the absorption process has the potential to remove biological pollutants such as bacteria, fungi, and viruses, improving indoor air quality. This paper experimentally studies the Moisture removal rate in a solar powered liquid desiccant air conditioning system using Triethylene Glycol as a desiccant. An evacuated solar boiler was used for desiccant regeneration. During the experimental investigation, the inlet parameters, including air flow rate, humidity ratio, desiccant flow rate, and concentration are varied. The effect of these variables on the moisture removal rate was studied. It is found that the moisture removal rate increases with increasing the inlet air flow rate, inlet air humidity ratio, desiccant flow rate, and desiccant solution concentration.

Nomenclature

A	cross sectional area of dehumidifier (m^2)
m	moisture evaporation rate (g/s)
P	Pressure (mmHg or KPa)
T	Temperature C^0
Y	Air humidity ratio (kg water/kg dry air)

Abbreviations :
TEG : Triethylene Glycol

Subscripts:

a	Air
des	Desiccant
remo	Removal
in	Inlet
out	Out let
y	Air humidity ratio

INTRODUCTION:

Liquid desiccant systems basically consist of dehumidifier where the moisture was removed from the air and regenerator where the moisture was removed from the liquid desiccant by using heating source like solar heating. They are used as an alternative to the conventional vapour compression systems. The characteristic of these systems is that the electrical energy consumption can be reduced [1, 2]. Thus there is potential for cost savings by using desiccant cooling, especially in applications where the latent cooling load comprises a large portion of the total cooling load. For example Burns et al [3] found that utilizing desiccant cooling in a supermarket reduced the cost of air conditioning by 60% as compared to conventional vapor compression system. Therefore, research leading to reliable, energy efficient, and cost competitive desiccant system is warranted.

Desiccant technology has become a valuable tool in the industry's arsenal of space conditioning options. The use of desiccant cooling and dehumidification systems for building comfort conditioning has increased steadily during the past several years. In addition to dehumidification, an added benefit of some desiccants is their ability to absorb inorganic and organic contaminants in the air. Moreover, the absorption process has the potential to remove biological pollutants such as bacteria, fungi, and viruses, improving indoor air quality [4,5].

One of the most efficient types of dehumidifiers is the inner cooled dehumidifier using cooling coils to remove the heat generated from dehumidification. Yoon et al. [6] used a dehumidifier with one channel flowing air and desiccant solution and another channel flowing cooling water from the cooling tower. Khan and Sulsona [7] chose the apparatus like that used by Yoon, except that the cooling water is replaced by refrigerant in their hybrid system to realize the dehumidification of the process air and gave the profiles of humidity and temperature of the process air, the concentration and temperature of the desiccant solution, as well as the quality of refrigerant in the cooling coil. An air dehumidifier where the air is brought in contact with a desiccant (TEG) film falling over a finned tube heat exchanger was analyzed by Peng and Howell [8]. Chebbah [9], presented results from performance modeling of a finned tube coil desiccant air contactor operating at nearly isothermal conditions. He found that both temperature and humidity of the air leaving the dehumidifier increased with increasing inlet desiccant temperature. Also he found that increasing the inlet desiccant concentration resulted in a lower humidity of the air leaving the dehumidifier. Jain et al. [10] experimentally tests the performance of the internally cooled dehumidifier, in which the flow direction of air to desiccant is parallel. LiBr aqueous solution is taken as liquid desiccant and cooling water from

cooling tower is used as cooling fluid to cool the desiccant in a counter-flow direction. Zhao [11] tested a dehumidifiers in which the flow direction of air to desiccant is counter- flow and the flow direction of cooling fluid to desiccant is cross- flow. Lowenstein et al. [12,13] experimentally tests the performance of a kind of cross-flow dehumidifier, in which the cooling water is in parallel-flow to the desiccant.

This paper aims at investigating experimentally, the performance of an internally cooled dehumidifier using Triethylene Glycol (TEG) as a desiccant and a solar energy as a heating source in the regeneration process. The effects of the dehumidifier inlet parameters such as air flow rate, air humidity ratio, desiccant flow rate, and desiccant concentration on the performance of the dehumidification process are to be studied. The performance of this process will be evaluated in terms of moisture removal rate.

INSTRUMENTATION

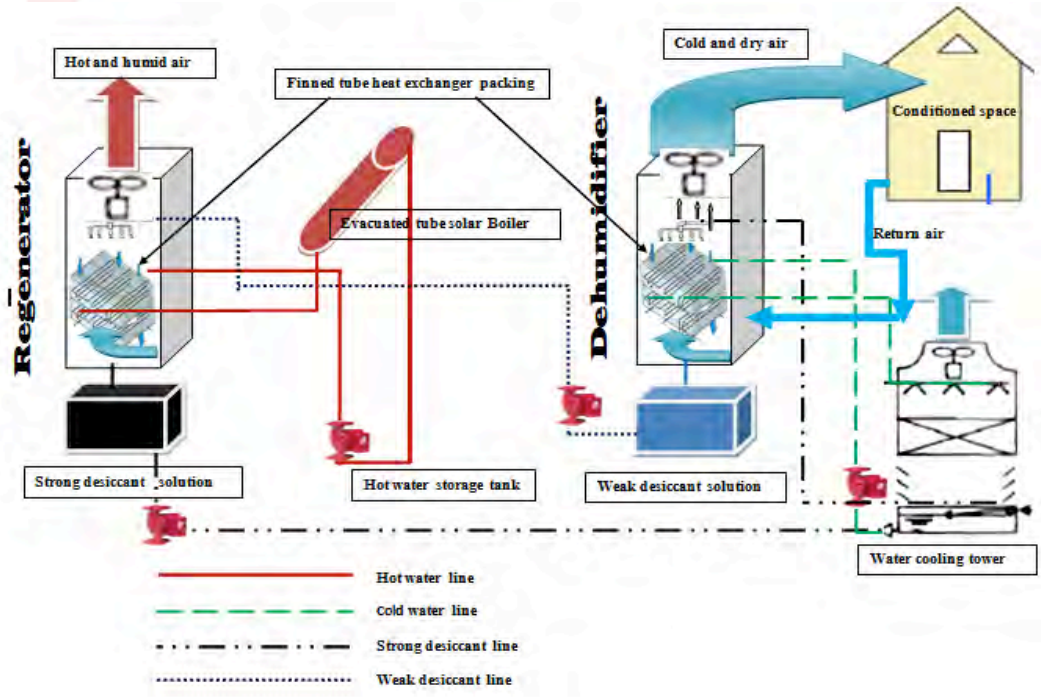
The inlet, outlet temperature and relative humidity of the dehumidifier were measured by KOBOLD AFK-E Humidity/Temperature meter (made by KOBOLD Instruments Inc – Germany). This meter operates in the range of (0-100% for relative humidity and (-40 to +180 C) for temperature. with RTD metal probes 3 meters long, and digital readout display at the end. The inlet and outlet air flow rate of the dehumidifier were measured by a portable digital anemometer CFM Master 8901 Vane Digital Anemometer (obtained from Omega Engineering). It measures volume flow rate, air velocity, free area, and Temperature. The inlet and outlet temperature for cooling water were measured by a digital thermometer (made by P&M, China). This thermometer operates in the range of (0 to +100 C) with RTD metal probes 2 meter long at the end and digital display reading. The inlet and outlet temperature for strong desiccant were measured by a digital thermometers (made by P & M, China), operate in the range of (0 to +100 C) with 1 meter RTD metal probes at the end and digital display reading. The flow rate for cooling water was measured by flow meters (made by AMI). It operates in the range of (0 to +130) liter per minute. The flow rate for strong desiccant were measured by flow meters (made by Blue White Industries CADADA), operate in the range of (0 to +280 LPM) liter per minute. The flow rate control of the cooling water and strong desiccant during the experiments are done via valves fixed after each of the four pumps. The air flow rate control in the dehumidifier and cooling tower is done by adjustable speed switch made by FILUX. The TEG concentration was determined by a calibrated hand refractometer (made by ATAGO, China) it has operative range of (1.445- 1.52).

EXPERIMENTAL SETUP

Fig.1 shows the schematic diagram of the system used in this research. The whole system was fabricated in the AlGhaya electromechanical workshop -Khartoum, and assembled on the roof of the Northern Building of the Faculty of Engineering –University of Khartoum-Sudan. The dehumidifier composed of inner cooled fined tubes heat exchanger as a packing material, intake –inlet air ducts, cooling tower, strong desiccant storage tank, and circulating pumps. The regenerator composed of inner heated fined tubes heat exchanger as a packing material, intake –inlet air ducts, solar boiler, weak desiccant storage tank, and circulating pumps.

The system uses a 95% Triethylene Glycol (TEG) solution as desiccant. The TEG solution was distributed uniformly over the heat exchanger. The solution passes through the fins of a plate

heat exchanger which holds cold water from the cooling tower by the cold water pump. The solution cools as a result of passing through the fins and is sprinkled down in a laminar flow configuration. The fresh air, which was drawn by the axial fan enter from the bottom of the vertical section of the dehumidifier in a counter manner to the desiccant and flows over the cold surface of the heat exchanger fins. The contact between the humid air under a high vapor pressure and the cold desiccant solution under very low vapor pressure drives the water vapor from the air to the desiccant solution. In addition, cooling of the air occurs due to the contact with the cold solution. The final result of the activity in this section is that the air is dehumidified and cooled down before it is supplied to the conditioned space. The diluted desiccant is circulated to a regenerator which uses hot water from solar boiler. The hot concentrated desiccant is cooled to a certain temperature by passing it through the cooling water tank before distributing it again over the finned tube heat exchanger in the dehumidifier. The desiccant temperature and concentration were measured before running each experiment.



The performance of the dehumidifier was evaluated by the moisture removal rate. The moisture removal rate in this paper was calculated by using the theoretical model (finite difference model) given by Ahmed .M Ahmed [14], the experimental data and the correlation found in the literature. The moisture removal rate from the air was calculated from the following relation:

$$\dot{m}_{remov} = (Y_{in} - Y_{out}).A$$

Where Y_{in} and Y_{out} are the absolute humilities of the air at the inlet and outlet conditions, respectively, and A is the column cross-sectional area. The moisture removal rate was also calculated from the correlation developed by Abdul- Wahab et al. [15] shown below.

RESULTS AND DISCUSSION:

The moisture removal rates found from the experimental data were presented graphically with the design variables. The parameters that were varied during the experiments included the inlet

air flow rate, inlet air humidity ratio, desiccant solution flow rate, and desiccant solution concentration.

The Effect of air flow rate

The variations of moisture removal rate as a function of the air flow rate are shown in Fig.2. A higher air flow rate will removes the dehumidified air more rapidly away from the interface, thereby reducing the humidity gradient between the solution and the air stream at the interface. It will enhance the mass transfer coefficient. These results are in good agreement with studies reported by Chen et al. [16] , Oberg and Goswami [17], Fumo and Goswami [18] and Zurigat et al. [19].

The Effect of Inlet Air inlet humidity ratio

The influence of air inlet humidity ratio on the dehumidifier performance is shown in Fig.3. Moisture removal rate increases with increasing air inlet humidity ratio. In fact, increasing the air inlet humidity ratio caused an increase the driving force and hence increases the mass transfer potential within the dehumidifier, and the result is increase in the moisture removal rate. The results showed good agreement with those of Chen et al. [16] , Patnaik et al. [21] , Oberg and Goswami [17] and Fumo and Goswami [18].

Effect of desiccant solution flow rate:

The influence of desiccant solution flow rate on the dehumidifier performance is shown in Fig.4. Moisture removal rate is enhanced when the flow rate of desiccant solution is increased. This is due to the good wetting of the packing when high liquid flow rates were employed based on liquid to air flow rate ratios. The driving potential for heat transfer is greater when the temperature difference between desiccant solution and moist air remains high as a result of higher solution flow rate. Increasing the desiccant flow rate increase the mass transfer coefficient between the desiccant and the air in the dehumidifier. This result is in agreement with studies reported by Facto and Grossman [20] , Patnaik et al. [21], Pontis and Lenz [22] , Zurigat et al. [19], Gandhidsan [23], and Elsarraj [24].

The effect of Desiccant inlet concentration

Fig.5. shows the effect of desiccant inlet concentration on the dehumidifier performance. The moisture removal rate was increased significantly with increasing desiccant inlet concentration. The reason is that by increasing the desiccant inlet concentration the desiccant surface vapor pressure decrease, and hence increase the average water vapor pressure difference between the desiccant and air in the dehumidifier, leading to lower air outlet humidity ratio and, hence, higher moisture removal rate.

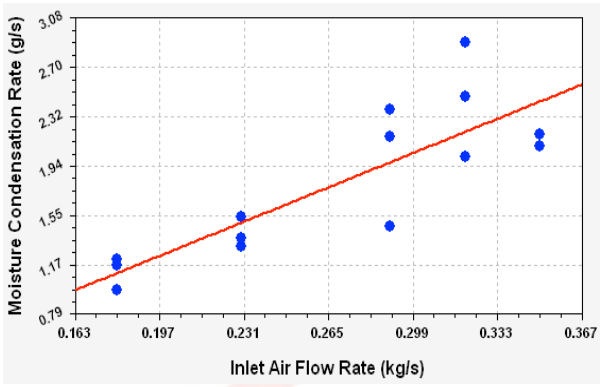


Fig. 2. The Effect of Air Flow Rate on the Moisture Condensation Rate

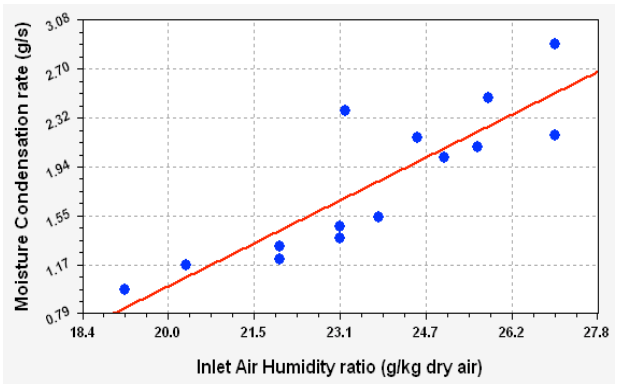


Fig. 3. The Effect of Inlet Air Humidity Ratio on the Moisture Condensation Rate

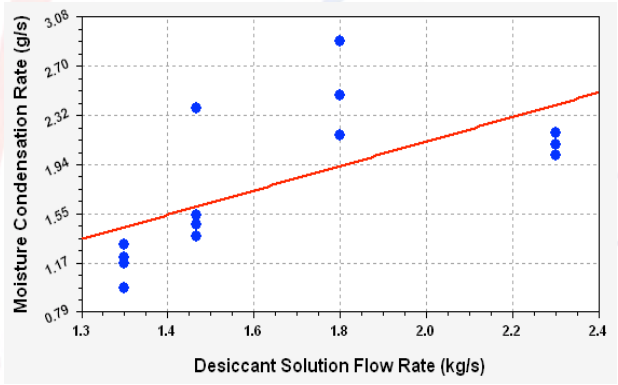


Fig. 4. The Effect of Desiccant Solution Flow Rate on the Moisture Condensation Rate

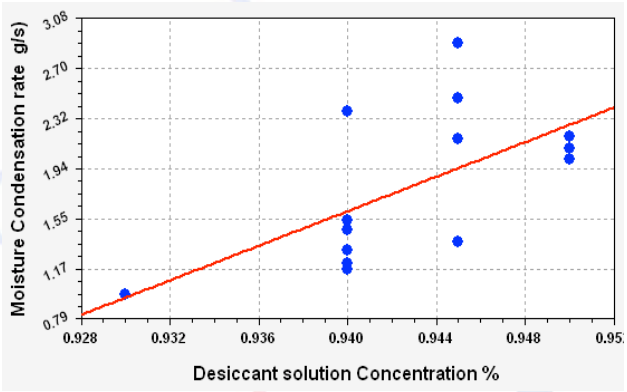


Fig. 5. The Effect of Desiccant Concentration on the Moisture Condensation Rate

CONCLUSIONS:

The performance of an internally cooled TEG liquid desiccant dehumidifier was investigated experimentally in this study. The results showed that as the inlet air flow rate and the inlet air humidity ratio were increased, the moisture removal rate increases. These results also showed that by increasing the inlet desiccant concentration and flow rate, the moisture removal rate increases. These results are in good agreement with those published by others.

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Investigation on the Wave Reduction of a Series of Fixed Floating Structures in Tandem Using a Regularized Meshless Method

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Abstract:

The wave reduction capability of a series of floating structures partially submerged and fixed in tandem on water surface is investigated. Linear water waves are impinging on the structures in the normal direction. The wave field is solved by using a regularized meshless method (RMM). RMM is a modification of the Method of Fundamental Solutions (MFS) widely used in solving boundary value problems. In MFS, a number of source points are placed outside of the boundaries of the problem domain and the potential of these source points are solved by imposing boundary conditions on the collocation points distributed on the domain boundaries. The potential of the wave field is then obtained by superposition of the source points. The accuracy of MFS is related to the spatial distribution of the source points. However, the appropriate locations of these source points are debatable and are usually determined by a trial-and-error procedure. To resolve this problem, a regularized meshless method (RMM) has been proposed which utilizes a regularization technique in the formulation procedure. As a result, the source points can be placed directly on the boundaries, which not only resolves the debatable problem of fictitious boundaries in MFS but also improves the reliability of the results. In this paper, the technique of RMM is applied to solve the wave field induced by a series fixed floating structures in tandem to investigate the wave reduction capability of these structures. The transmission and reflection coefficients of the waves ahead of the structures are calculated. The results show that the transmission coefficient is reduced with larger submerge depth of the structures and with more rows of the structures, and total reflection can be achieved with proper configuration of the structures. The investigation results might be useful for the planning and design of wave reduction facilities.

Introduction

Wave reduction facilities are common protection measures for the safety of shoreline or harbours. Upon various wave reduction measures, using a series of fixed floating breakwaters placed in tandem in front of shoreline or harbour to reduce the transmitted wave has been investigated extensively (Isaacson et al., 1995; Murali et al., 2005; Wang et al., 2010;). To evaluate the wave reduction capability of the structures, a reliable mean for correct wave field prediction is an essential part. Most of the researches tackle this problem by using numerical calculations (Abul-Azm and Williams, 1997, Ijima et al., 1980) or flume experiments (Sanmasiraj et al.,1998). This paper aims to investigate a new approach for wave field calculation by utilize the Regularized Meshless Method (RMM) proposed by Chen et al. (2006). RMM is a modification of the Method of Fundamental Solutions (MFS) widely used in solving boundary value problems. In MFS, a number of source points are placed outside of the boundaries of the problem domain and the potential of these source points are solved by imposing boundary conditions on the collocation points distributed on the domain boundaries. The potential of the wave field is then obtained by superposition of the source points. The accuracy of MFS is related to the spatial distribution of the source points. However, the appropriate locations of these source points are debatable and are usually determined by a trial-and-error procedure. To resolve this problem, a regularized meshless method (RMM) has been proposed which utilizes a regularization technique in the formulation procedure. As a result, the source points can be placed directly on the boundaries, which not only resolves the debatable problem of fictitious boundaries in MFS but also improves the reliability of the results.

In this paper, the technique of RMM is applied to solve the wave field induced by a series fixed floating pontoons in tandem to investigate the wave reduction capability of the structure. The results are verified with previous researches of Abul-Azm and Gesraha (2000) and Cho, et al. (2004). Various factors affecting the wave reduction capability of the structures are investigated based on the calculations, including number of the pontoons, submerged depth of the pontoons, and the width of the pontoons.

Governing equation

Consider vertical barriers located in tandem on the water surface as shown in Fig.1. A wave train with a frequency σ propagates towards the barrier in a constant water depth h. Assuming the fluid is inviscid and incompressible, and the flow is irrotational, the wave field may be represented by the velocity potential $\Phi(x,y,z,t)$ which satisfies the Laplace equation as

$$\nabla^2\Phi(x,y,z,t)=0 \tag{1}$$

According to the uniformity of the water depth in the z-axis and the periodicity in time, the potential $A^{(i)}(s^i,x^i)$ of fluid motion can be expressed as:

$$\Phi(x,y,z,t)=\phi(x,y)\mathrm{e}^{i\sigma t} \tag{2}$$

where k is the wave number which satisfies the dispersion relation:

$$\sigma^2 = gk\tanh(kh) \tag{3}$$

where g is the acceleration of gravity. The unknown function, $\phi(x,y)$, describes the fluctuation of the potential on the x-y plane. Substitution of Eq. (2) into (1) yields the Laplace equation as follows:

$$\nabla^2\phi(x,y)=0, \quad (x,y)\in D \tag{4}$$

where D is the domain of interest.

Boundary conditions

The BCs of the interested domain are summarized as:
1. The linearized free water surface boundary condition:

$$\frac{\partial\phi(x,y)}{\partial y}-\frac{\sigma^2\phi(x,y)}{\mathrm{g}}=0 \tag{5}$$

2. Seabed and breakwater boundary conditions:
Rigid boundary condition:

$$\frac{\partial\phi(x,y)}{\partial n}=0 \tag{6}$$

where n is boundary normal vector.
3. Radiation condition at infinity:

$$\lim_{x\to\infty} x^{\frac{1}{2}}\left[\frac{\partial\phi(\mathrm{x,y})}{\partial x}-ik\phi(\mathrm{x,y})\right]\to 0 \tag{7}$$

4. The boundary conditions on the fictitious interfaces:
As for the infinite strip problem, the domain can be divided into three regions after introducing two pseudo-boundaries on both sides of the barrier, $x=\pm l$, as shown in Fig.2. The potential in region I without energy loss can be expressed as:

$$\phi^{(1)}(x,y)=[\mathrm{e}^{ik(x+l)}+R\mathrm{e}^{-ik(x\ l)}]\frac{\cosh k(h+y)}{\cosh kh} \tag{8}$$

where the superscript of $\phi^{(1)}(x,y)$ denotes the region number, R is the reflection coefficient. The potential in region III without energy loss can be expressed as:

$$\phi^{(3)}(x,y)=T\mathrm{e}^{ik(x-l)}\frac{\cosh k(h+y)}{\cosh kh} \tag{9}$$

where T is the transmission coefficient. According to the property of continuity across boundary on the fictitious interfaces ($x=\pm l$), we can derive the reflection and transmission coefficients as follows:

$$R=1+\frac{k}{n_0\sinh(kh)}\int_{-h}^{0}\phi^{(2)}(\mathrm{-l,y})\cosh k(h+y)dy \tag{10}$$

$$T=\frac{k}{n_0\sinh(kh)}\int_{-h}^{0}\phi^{(2)}(\mathrm{l,y})\cosh k(h+y)dy \tag{11}$$

where $n_0=\frac{1}{2}\left(1+\frac{2kh}{\sinh(2kh)}\right)$

Solution representation by using the RMM

By employing the RBF technique (Chen and Tanaka, 2002), the solution of the problem can be approximated in terms of the strength of the singularities (s^j) as

$$\phi(x^i)=\sum_{j=1}^{N}A^{(i)}(s^j,x^i)\alpha^j, \quad x\in D^{(i)} \tag{12}$$

$$\psi(x^i) = \sum_{j=1}^{N} B^{(i)}(s^j, x^i)\alpha^j, \quad x \in D^{(i)} \tag{13}$$

where $A^{(i)}(s^j, x^i)$ is the RBF and the superscript of $A^{(i)}(s^i, x^i)$ and $D^{(i)}$ denotes the interior domain, x^i is the i-th field point (observation point), α^j are the unknown coefficients, N is the number of source points (s^j), and $B^{(i)}(s^j, x^i) = \frac{\partial A^{(i)}(s^j, x^i)}{\partial n_x}$. The coefficients $\{\alpha^j\}_{j=1}^N$ are determined such that BC is satisfied at the boundary points ($\{x^i\}_{i=1}^N$). By collocating N observation points, $x^i (i = 1,2,\cdots,N)$ on the real boundary, we have the following $N \times N$ linear systems in the form of

$$\left\{\bar{\phi}^i\right\} = \begin{bmatrix} a_{1,1} & a_{1,2} & \text{L} & a_{1,N} \\ a_{2,1} & a_{2,2} & \text{L} & a_{2,N} \\ \text{M} & \text{M} & \text{O} & \text{M} \\ a_{N,1} & a_{N,2} & \text{L} & a_{N,N} \end{bmatrix} \left\{\alpha^j\right\} = \left[A^{(i)}\right]\left\{\alpha^j\right\} \tag{14}$$

$$\left\{\bar{\psi}^i\right\} = \begin{bmatrix} b_{1,1} & b_{1,2} & \text{L} & b_{1,N} \\ b_{2,1} & b_{2,2} & \text{L} & b_{2,N} \\ \text{M} & \text{M} & \text{O} & \text{M} \\ b_{N,1} & b_{N,2} & \text{L} & b_{N,N} \end{bmatrix} \left\{\alpha^j\right\} = \left[B^{(i)}\right]\left\{\alpha^j\right\} \tag{15}$$

where

$$a_{i,j} = A^{(i)}(s^j, x^i), \quad i, j = 1,2,\text{L}\ , N \tag{16}$$

$$b_{i,j} = B^{(i)}(s^j, x^i), \quad i, j = 1,2,\text{L}\ , N \tag{17}$$

The chosen RBFs are the double layer potentials from the potential theory and are given as:

$$A^e(s^j, x^i) = -\frac{((x_i - s_j)\cdot n_j)}{\bar{r}_{ij}^2} \tag{18}$$

$$B^e(s^j, x^i) = 2\frac{((x_i - s_j)\cdot n_j)((x_i - s_j)\cdot \bar{n}_i)}{\bar{r}_{ij}^4} - \frac{(n_j \cdot \bar{n}_i)}{\bar{r}_{ij}^2} \tag{19}$$

where (,) is the inner product of two vectors and $r_{ij} = \sum_{k=1}^{2} \left|s_k^j - x_k^i\right|$, $y_k n_k = \sum_{k=1}^{2} \left(x_k^i - s_k^j\right) n_k$, n_k is the k-th component of the outward normal vector at source point s^j; and $\bar{n}_k$ is the k-th component of the outward normal vector at field point x^i. It is noted that the double layer potentials in Eqs. (18) and (19) have both singularity and hypersingularity at the origin, which leads to troublesome singular kernels and controversial auxiliary boundary for the MFS. The off-set distance between the off-set (auxiliary) boundary (B') and the real boundary (B) needs to be chosen deliberately. To overcome this drawback, s^j is distributed on the real boundary by using the following proposed regularized techniques. The rationale for choosing the double layer potential is to take advantage of the regularization of the subtracting and adding-back technique, so that the off-set distance is no longer needed when evaluating the diagonal coefficients of influence matrices explained in the next section.

Derivation for diagonal coefficients

When collocation point, x^i approaches to the source point s^j, the kernels, the kernels in Eqs. (18) and (19) have the singularity and hypersingular. Therefore, the kernels need to be regularized through special treatment as

$$\begin{aligned}\bar{\phi}(x^i) &= \sum_{j=1}^{N} A^{(i)}(s^j, x^i)\alpha^j - \sum_{j=1}^{N} A^{(e)}(s^j, x^i)\alpha^i \\ &= \sum_{j=1}^{i-1} A^{(i)}(s^j, x^i)\alpha^j + \sum_{j=i+1}^{N} A^{(i)}(s^j, x^i)\alpha^j \\ &\quad -[\sum_{m=1}^{N} A^{(e)}(s^m, x^i) - A^{(e)}(s^i, x^i)]\alpha^i,\ x^i \in B\end{aligned} \tag{20}$$

$$\begin{aligned}\bar{\psi}(x^i) &= \sum_{j=1}^{N} B^{(i)}(s^j, x^i)\alpha^j - \sum_{j=1}^{N} B^{(e)}(s^j, x^i)\alpha^i \\ &= \sum_{j=1}^{i-1} B^{(i)}(s^j, x^i)\alpha^j + \sum_{j=i+1}^{N} B^{(i)}(s^j, x^i)\alpha^j \\ &\quad -[\sum_{m=1}^{N} B^{(e)}(s^m, x^i) - B^{(e)}(s^i, x^i)]\alpha^i,\ x^i \in B\end{aligned} \tag{21}$$

where $A^{(e)}(s^j, x^i)$ and $B^{(e)}(s^j, x^i)$ are the double layer potentials of the exterior problem of Laplace equation for the same domain, and

$$\sum_{j=1}^{N} A^{(e)}(s^j, x^i) = 0 \tag{22}$$

$$\sum_{j=1}^{N} B^{e}(s^j, x^i) = 0 \tag{23}$$

The original singular terms of $A^{(i)}(s^i, x^i)$ and $B^{(i)}(s^i, x^i)$ in Eqs. (12) and (13) have been transformed into regular terms of $-\left[\sum_{m=1}^{N} A^{(e)}\left(s^m, x^i\right) - A^{(e)}\left(s^i, x^i\right)\right]$ and $-\left[\sum_{m=1}^{N} B^{(e)}\left(s^m, x^i\right) - B^{(e)}\left(s^i, x^i\right)\right]$ in Eqs. (20) and (21), respectively. It should be pointed out that the terms of $\sum_{m=1}^{N} A^{(e)}\left(s^m, x^i\right)$ and $\sum_{m=1}^{N} A^{(e)}\left(s^m, x^i\right)$ are the adding-back terms, while the $A^{(i)}(s^i, x^i)$ and $B^{(i)}(s^i, x^i)$ are the subtracting terms in the two brackets for the special treatment technique. After using the regularized technique of subtracting and adding-back methods, we are able to remove the singularity and hypersingularity of the kernel functions.

Model verifications

The model was verified with the results obtained by Abul-Azm and Gesraha (2000) by using the method of eigenfunction expansion. Fig. 3 shows the calculated reflection coefficient R in region I as a function of kh for a rectangular pontoon. For comparison, the results of Abul-Azm and Gesraha are also shown in the figure. As seen in the figure, the model gives good agreement with the analytical solution of the case study, which verify the accuracy of the proposed model.

Discussions

The model is utilized to investigate the wave reduction capability of the floating

structures. Variables studied including (1) number of pontoons, N_f, (2) relative submergence of the pontoon, d_f/h, and (3) relative width of the pontoon, w_f/h.
Fig. 4 shows the reflection coefficient in region I as a function of N. It is seen in the figure that the reflection is increasing with higher N_f, indicating that the wave reduction capability of the structure is higher with more pontoons. It is also noted that R drops down to 0 for certain 2S/L values, indicating that the structure might lose its wave reduction function if the distance between the pontoons is not properly designed. The figure also shows that when 2S/L is within the range of about 0.8 to 1.3, R is about 0.9 and most of the oncoming waves reflect. This provides a useful guideline on the design of the distance between the pontoons.
Fig. 5 shows the variation of the reflection coefficient R with respect to the relative submergence of the pontoons. As the figure shows, R is higher with larger submergence. It is noted that, when d_f/h increases, the range of 2S/L for high reflection is also wider. For example, for d_f/h=0.25, R reaches 0.9 for 2S/L within the range of 0.9 to 1.2. For d_f/h=0.75, R reaches 0.9 for 2S/L within a wider range of 0.6 to 1.3. This indicates that with deeper submergence of the pontoons, the restriction on the distance between the pontoons is lesser.
Fig. 6 shows the variation of R with respect to the relative width of the pontoons, w_f/h. It appears that R increases with increasing w_f/h. It is also seen that, with larger w_f/h, the range of 2S/L for higher R is wider, indicating less restriction on S for larger w_f/h.

Conclusions

A Regularized meshless method (RMM) was applied to study the wave field induced by a series floating breakwaters placed in tandem. The result shows favourable agreements comparing to the analytical solutions. Calculations show that the wave reduction capability of the structure is higher if the breakwater consists of more pontoons within. The results also show that the distance between the pontoons, S, is an important design factor. For certain values of 2S/L, the breakwater might lose its functionality. With deeper submergence and larger width of the pontoons, the restriction on S is lesser, and the range of 2S/L to achieve high reflection is wider.

Acknowledgements

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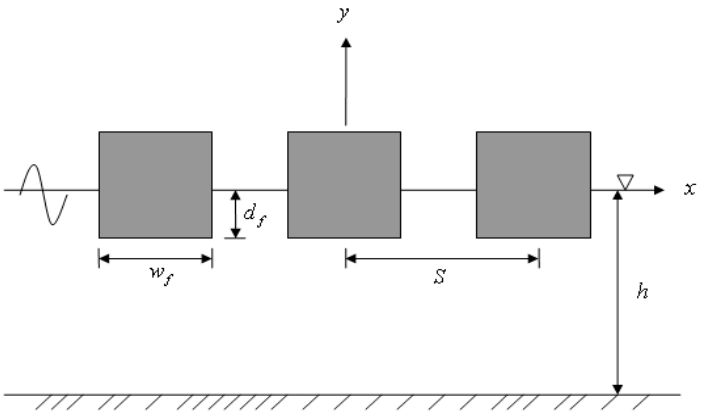

Figure 1. Definition sketch of the floating structures

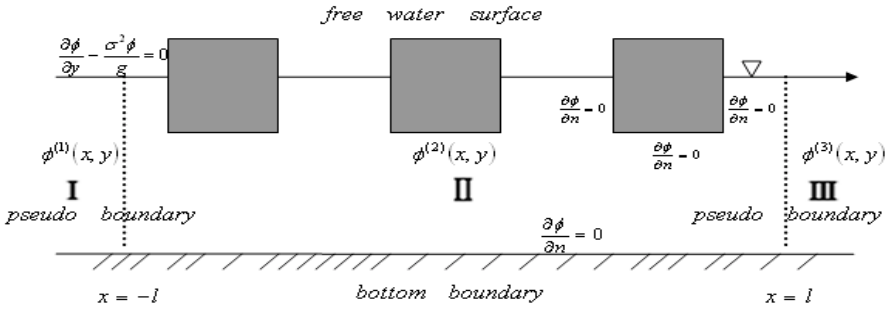

Figure 2. Boundary conditions for the problem

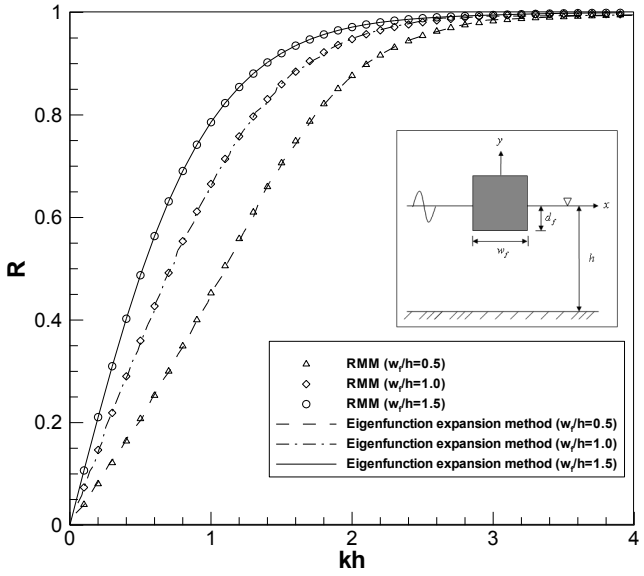

Figure 3. Comparison of the results (d_f/h=0.25)

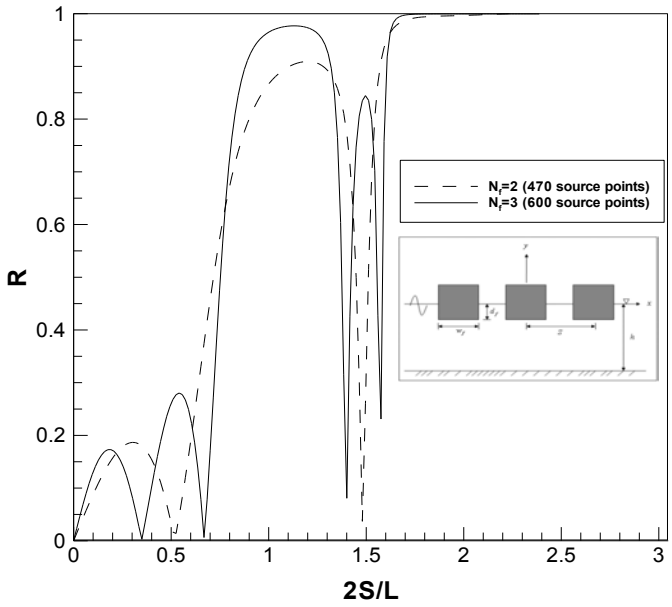

Figure 4. R as a function of N_f (d_f/h=0.25, w_f/h=0.5)

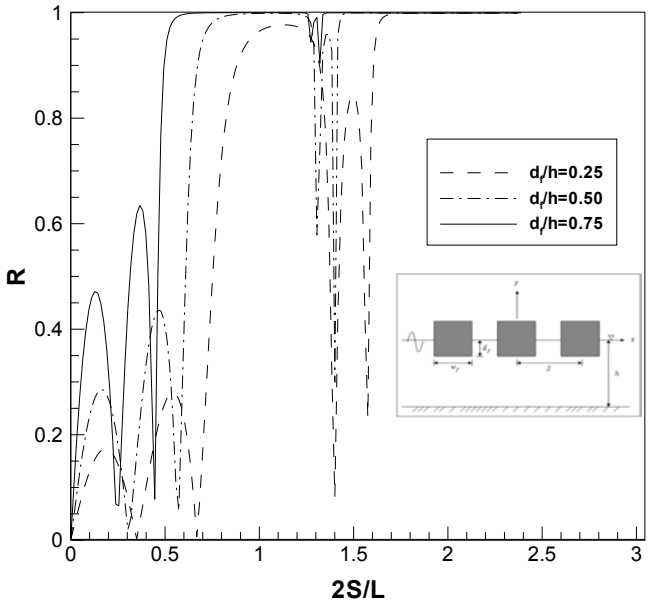

Figure 5. *R* as a function of d_f/h (w_f/h=0.5)

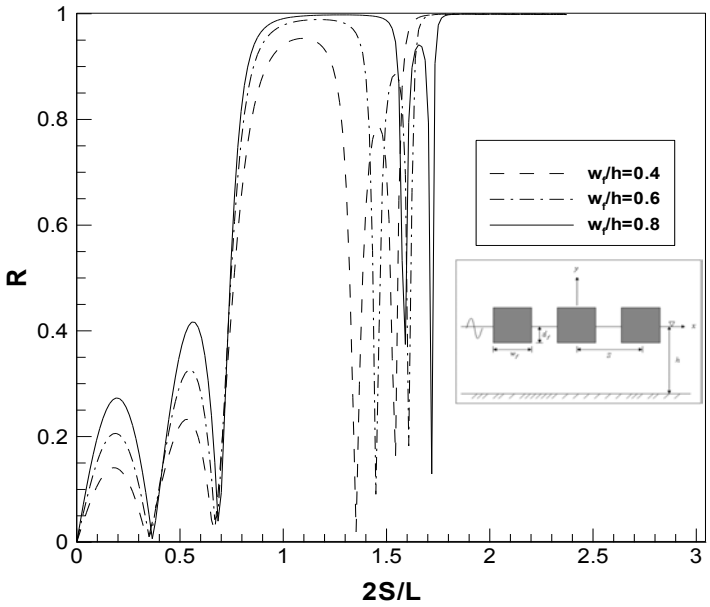

Figure 6. *R* as a function of w_f/h (d_f/h =0.25)

Natural Improvements of Geochemical Conditions of Acid Sulfate Soils Caused by Free Tidal Inundation and its Effects on the Mangrove Seedlings

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Abstract:

Acid sulfate soils (ASS) are one of the stressor factors that cause many mangrove restoration projects to fail. Achieving successful rehabilitation in an ASS affected area requires an understanding of the geochemical conditions that influence the establishment and growth of mangrove seedlings.

Tidal inundation influences many physic and geochemical factors, and this condition are made even more complex by the oxidation of pyrite. This study evaluated the effect of tidal inundation on geochemical conditions on sub sediments near roots and their impacts on the density, establishment, and growth of mangrove seedlings. This study is also to seek the answer the question: In which geochemical conditions can mangrove seedlings establish naturally, and/or be replanted in abandoned aquaculture ponds?

The study area was in abandoned ponds area complex situated in the Mare District, adjacent to Bone Bay, South Sulawesi, Indonesia. The study used six replications of pH, pH_{fox}, redox potential, organic content, water soluble sulfate, KCl extractable sulfur, peroxide oxididable sulfur, and grain size of sub sediments near roots (10 - 15 cm) of sediment cores were measured. Three replications of pyrite analysis were conducted for the surface and sub sediments. The density, establishment and the growth of Rhizophoraceae were also determined.

Free tidal inundation at abandoned pond site improved the sediment quality. The high density, establishment, and growth of mangrove seedlings were characterized by freely drained areas with a higher pH (field and oxidisable), lower organic content, and high proportion of silt/clay. Higher density and growth also correlated to reduced environments. Measured sulfur species did not influence the density, establishment, and growth of the seedlings directly. The supply of propagules from the mangrove stands, or access from good waterways were also important for seedlings to establish naturally.

1. Introduction

The destruction of mangroves ecosystems for aquaculture ponds has impacted negatively on the ponds due to disturbance of acid sulfate soils (ASS) causing poor water quality, fish disease, and fish mortality. This condition has been recorded in many places, but particularly in areas of Southeast Asia [1] such as Indonesia, Vietnam, and in Costa Rica. Since this condition makes aquaculture unsuitable and the remediation techniques are costly, most ASS affected ponds have been abandoned. Therefore, restoring mangoves to regain their mangrove function is very important.

Many experts claimed that ASS is one stressor factor that results in the failure of some mangrove restoration projects. Additionally, there is some evidence that mangrove seedlings have been affected in some abandoned ponds (e.g. in Tiwoho, North Sulawesi, Indonesia) [2]. Here, natural revegetation has occurred in abandoned ponds that have had their dikes breached, highlighting the role of suitable hydrology in mangrove restoration [2].

Suitable physical conditions are necessary for seedlings to become established [3], where hydrology has become the focus of attention for mangrove restoration projects as it plays a significant role in self-repair, or secondary succession [4].

Despite widespread knowledge on the role of hydrology in mangrove restoration, the nature of geochemistry in ASS areas that may be affected by hydrological factors remains poor. Tidal inundation influences many physical and geochemical factors, and this condition is made even more complex by the oxidation of pyrite that involves a number of redox reactions and microbial activities [5]. Therefore, knowledge on geochemistry in ASS areas is important because it influences the establishment of mangrove seedlings.

This study evaluated the effect of tidal inundation on some physical and geochemical variables on sub sediments to better understand their impacts on aspects of mangrove biology. This study also examined the geochemical conditions required for succesful establishment of mangrove seedlings either naturally, and/or replanted, in abandoned aquaculture ponds, as well as the relationships between those conditions and the growth of the mangrove seedlings.

2. The description of study area, procedure and analysis

2.1. Description of study area

The field study was conducted from July to December 2011 (rainy season) in six environments in an abandoned pond complex, and in one control area in Mare ($04^{o}51'S$, $120^{o}18'E$), district of Bone, province of South Sulawesi Selatan, Indonesia. The ponds complex area was about 70 ha and was previously a mangrove forest that was cleared for extensive shrimp ponds.

2.2. Procedure

Six replicates of 15 cm sediment cores were collected around mangrove seedlings at each site. A seedling was defined as being no more than one meter high, with no branches. Density and survival rates of plants were estimated by counting, marking and measuring all individuals in six 1m x 1m plots randomly placed at each site. Plots were revisited at the end of the three month period trial, and the same data collected. The plant height measured was the above ground height. The relative growth rate (RGR) of the seedlings was determined based on the height [6].

Mangrove seedlings and sediments of sub layer sediments (10-15cm) were analyzed for several variables, i.e. peroxide oxidisable pH (pHfox), redox potential (Eh) using probemeter. The analyses of total peroxide oxidisable sulfur (S_{POS}) were obtained by subtracting the peroxide sulfur (S_P) with

KCl-extractable sulfur (S_{KCl}) [7]. The water-soluble sulfate (SO_4^{2-}) levels were analyzed using the turbidimetry method and measured by a spectrophotometer. Determination of the pyrite percentage was measured through Titratable Sulfidic Acidity (TSA) analysis [8]. The concentration of organic content was determined using the Loss on Ignition (LOI) method. The analysis of grain size of the sediment was done using classical wet sieve analysis.

2.3. Statistical analysis

The Kruskal Wallis analysis was used to examine the difference between density and growth values in the study area. Principle Component Analysis (PCA) was employed to identify biogeochemical trends. Standardised regression was used to examine the relationship between the density, growth and other physical and geochemical variables. The Pearson rank correlation was employed to identify the correlation between the biological variables and physico geochemical variables.

3. Results and Discussion

In general, the sediments environments in abandoned ponds complex were degraded due to ASS, except Site 6. Table 1 shows a similar trend of variables between Site 6 that affected by free tidal inundation and the Control site (Site 7). This demonstrated the effect of tidal inundation on the improvement of geochemical condition such as: higher pH, reduce environment, lower organic content, and lower sulfur species.

Table 1. Sub layer sediment properties and porewater sulfide of the study area

Site	pH	pH_{fox}	Eh (mV)	LOI (%)	Water sol SO_4 (%)	SKCl (%)	SPOS (%)
1	6.11 ± 0.43	3.64 + 0.77	90 ± 117	25.16 ± 9.94	0.11 ± 0.10	0.67 ± 0.50	2.09 ± 0.52
2	5.62 ± 0.26	4.26 ± 0.61	81 ± 199	20.43 ± 2.79	0.10 ± 0.03	0.58 ± 0.16	1.99 ± 0.70
3	5.26 ± 0.56	3.79 ± 0.35	123 ± 121	24.14 ± 6.05	0.07 ± 0.05	0.56 ± 0.52	1.07 ± 0.72
4	5.18 ± 0.45	3.53 ± 0.36	205 ± 34	23.80 ± 5.72	0.11 ± 0.05	0.79 ± 0.36	2.10 ± 0.31
5	6.02 ± 0.47	5.17 ± 0.76	37 ± 27	28.30 ± 0.89	0.09 ± 0.02	0.55 ± 0.19	1.90 ± 0.39
6	7.01 ± 0.18	6.31 ± 0.07	-83 + 134	8.79 ± 2.38	0.03 ± 0.02	0.27 ± 0.05	0.99 ± 0.40
7	7.22 ± 0.20	6.30 ± 0.28	-139 ± 67	7.12 ± 0.24	0.05 ± 0.01	0.28 ± 0.04	1.38 ± 0.22

The density and relative growth rate of mangroves in abandoned ponds sites was lower than in the Control site (Table 2). The already existing seedlings in Sites 4,5,6,7 survived during three months examination period therefore the density values remain stable. While, replantation of six *R. mucronata* seedlings in Site 1, ended in low survival rate, where only two seedlings survived in the period with poor development

Table 2. The density, establishment, and growth of mangrove seedlings in the study area (n=42)

Site	Density (n/m)		Establishment (%)		Height (cm)			RGR
	Before	After	Before	After	Before	After	Addition	
1	1.00 ± 0.00	0.33 ± 0.52	100.00 ± 0.00	33.33 ± 51.64	90.83 ± 7.55	91.83 ± 7.88	1.00 ± 1.55	0.0001 ± 0.0002
2	NA	NA	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA	NA	NA
4	2.00 ± 1.10	2.00 ± 1.10	100.00 ± 0.00	100.00 ± 0.00	32.00 ± 6.36	33.83 ± 6.37	1.83 ± 0.98	0.0006 ± 0.0004
5	4.67 ± 4.32	4.67 ± 4.32	100.00 ± 0.00	100.00 ± 0.00	27.00 ± 2.53	29.50 ± 3.02	2.50 ± 1.05	0.0010 ± 0.0004
6	3.67 ± 3.93	3.67 ± 3.93	100.00 ± 0.00	100.00 ± 0.00	25.17 ± 2.71	27.00 ± 2.68	1.83 ± 0.41	0.0008 ± 0.0002
7	7.33 ± 3.33	7.33 ± 3.33	100.00 ± 0.00	100.00 ± 0.00	35.92 ± 4.48	39.17 ± 4.07	3.25 ± 1.17	0.0010 ± 0.0004

The study area was dominated by silt/clay, particularly in Site 6 and 7. And, the color of sub layer sediments were commonly grey with combination of yellow or orange and organic matter in some sites. The average percentage of pyrite in sub sediments of Site 6 (3.26%) was different compared to the Control site (1.04%). The average value of pyrite in sub sediments of Site 6 was closer to those in other sites in abandoned ponds complex (1.52 – 5.35%). The average pyrite percentages in surface sediments in site 6 was relatively lower (1.04%) and were between the range of Control site value (0.61%) and other abandoned ponds area (1.32 – 3.11%).

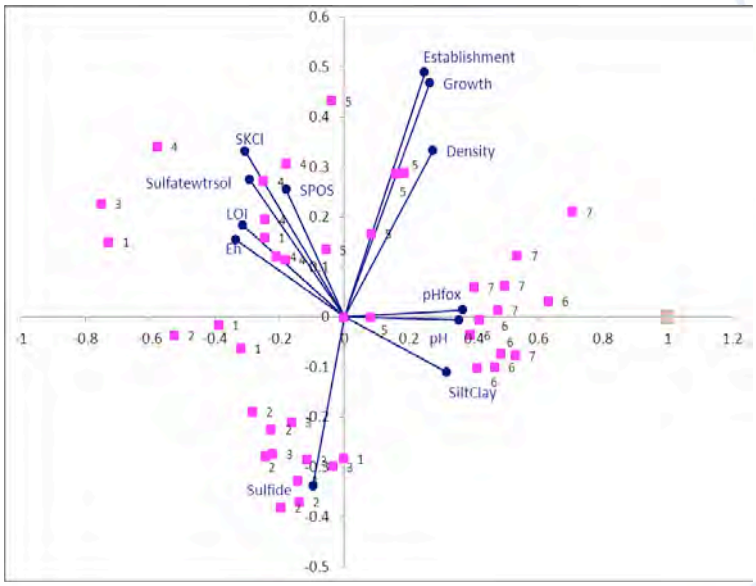

Fig. 2: The geochemical condition in the study area shown by the Principle Component Analysis. Numbers 1 to 7 represent Site numbers.

In general, there are three groups of density, establishment, and growth in the study area (Fig. 2). The first group is Site 4, 5, 6, and 7 with high density, establishment, and growth values. The second group is Site 1 that has very low density and growth values. The third group, Site 2 and 3, has zero values of density, establishment, and growth due to no *Rhizoporaceae* occuring in these sites. The first and second groups are recognized by their site location that influenced by water regime. The third group is recognized as a dry and water logged site (Site 2), with a small effect of inundation (Site 3).

The higher values of density, establishment, and growth of mangrove seedlings in the study area are associated with freely drained areas with a higher pH (field and oxidisable), lower organic content, high proportion of silt/clay, and non-jarosite top sediments. Higher density and growth also correlated to lower redox potential. Sulfur species did not influence the density, establishment, and growth of the seedlings directly.

Tidal seawater inundations at the sites for the first and second groups shifted the redox potential state to lower values from the previously oxidative environments. The degree of reducing environment was higher as the tidal inundation effect was higher. In this condition, sulfate reduction was produced through oxidation of organic matter [9]. The sulfate reduction consumed H^+ thus increased pH [10]. Decomposition of jarosite may also occur in such conditions [11]. Low acid environments enabled mangrove seedlings to establish better in sites under the first group.

The amount of pyrite at the top sediments in group 1 of abandoned ponds (Site 4, 5, and 6) are lower than at sub layer sediments, which is possibly caused by inundation washed up. It also appears that the sulfide oxidizing to sulfate occurred in Site 6 in low levels only because of the level of water soluble sulfate and KCl extractable sulfur, which provides the major sulfate, compared to other abandoned ponds sites.

The highest values of density, establishment, and growth of the *Rhizoporaceae* seedings occurred in Site 7 (Control) and Site 6. Inundation of abandoned ponds, which occur in Site 6 demonstrated improvement of sediment quality of the environment, which in turn provides a better environment for mangrove seedlings to establish. Broken dikes in Site 6 allow seawater to wash up the acid sulfate soils from this abandoned pond to cause higher pH and pH_{fox}, low or organic content, as well as disappearance of jarosite due to reduce environment [11].

In addition, the availability of propagules from mature mangroves near the sites provided an advantage for mangrove seedlings to establish. High values of density and growth at the sites in the third group can be due to these sites being situated in environments that have, or are close to, mature mangrove stands, which supply propagules to the sites. High silt content at these sites also promotes a strong medium for seedlings to establish.

Oxidative conditions occur in abandoned pond areas at Site 1, and particularly in the dry oxidative environment at Site 2 and 3. In these sites, under aerobic condition pyrite tends to oxidize and produce high concentration of sulfate and acid (sulfuric acid), which in turn decreases pH [11]. High concentration of organic matter in these areas provides sulfate to be adsorbed to organic matter as indicated by high percentages of total oxidisable sulfur that strongly correlated to organic content values (Table 3). Besides adsorption to organic matter, adsorption of sulfates onto hydrated Fe and Al oxide may also occur in these sites due to high levels of Al and Fe in the study area [12]. However, poor drainage particularly in the Site 2, leads to sulfate reduction, in sub layer sediments, and jarosite formation at the surface of sediment as a result of partial oxidation of the pyrite [11].

No seedlings were established at Sites 2 and 3 due to poor inundation which results in poor sediment quality as well as inhibiting propagules ability to enter the sites. The water flood in Site 2 is mainly from rain water. As such there is an absence of seedlings.

Site 1, which is located near Site 2 and 3, is furthest from the bay and does not have a mature mangrove stand nearby. Therefore Site 1 required replantation. During the three month evaluation period, two out of six *R. mucronata* seedlings replanted in this site were alive with poor development, indicating that the seedlings cannot easily establish in the area.

Table 3. The Pearson correlation analysis of the physico and geochemical variables (n=42)

	pH	pHfox	Eh	LOI	Wtrsol SO4	SKCl	S_P	S_{POS}	SiltClay
pH	1	.788**	-.730**	-.609**	-.488**	-.576**	-.434**	-.276	.659**
pHfox		1	-.731**	-.613**	-.505**	-.597**	-.464**	-.305*	.625**
Eh			1	.565**	.626**	.645**	.394**	.190	-.574**
LOI				1	.548**	.608**	.626**	.517**	-.564**
Wtrsol SO_4					1	.763**	.622**	.427**	-.464**
SKCl						1	.742**	.447**	-.559**
S_P							1	.931**	-.432**
S_{POS}								1	-.278
SiltClay									1

The physical and geochemical variables in the study area were strongly correlated (Table 3). Strong correlations between the values of organic content and all other physical and geochemical variables suggest that high organic content plays an important factor to form geochemical conditions in the study area.

4. Conclusion

In conclusion, free tidal inundation at abandoned pond sites improved the sediment quality. High values of density, establishment, and growth of mangrove seedlings were characterized by freely drained areas with a higher pH (field and oxidisable), lower organic content, and high proportion of silt/clay. Higher density and growth also correlated to reduced environments. Sulfur species did not influence the density, establishment, and growth of the seedlings directly. And, the supply of propagules from the mangrove stands, or access from good waterways were also important for seedlings to establish naturally.

5. Acknowledgements

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Unsustainability in Agricultural Areas

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Abstract:

Unsustainability in agricultural parts in this study consideres the factors that affect soil fertility, with focus on soil organic matter contents (SOM) and land use transformation index. Three difference of agricultural types, including paddy field, field crop and horticulture crop, in the central part of Thailand were sampling to analyze SOM, together with interview to the farmers to see agricultural practices. Percentage changes of agricultural areas to urban types were considered as land use transformation index. The results were found that SOM in the paddy fields were the highest. The lowers were horticulture and field crops, respectively. SOM in agricultural crops were dramatically less than the specification in their soil series. The change of agricultural areas to urban dwelling within the last decade has also been significant, especially in horticulture crop area.

Introduction

Unsustainability in agricultural areas in this study considers two main aspects. The first is soil fertility versus crop management. The second is land transformation, especially from agricultural to urban areas. Both issues indicate the sustainability of soil resource in agricultural areas.

As recognized, the active organic fraction in soil is reliable indicator of soil fertility. There are many factors which directly influenced on soil organic matter (SOM), as cited by many experts (see Pouyat, Yesilonis and Nowak, 2006; Woodbury, Heath and Smith, 2006; Zach, Tiessen and Noellemefer, 2006). In cultivated soil, the active fraction is influenced mainly by previous management. However, in order to gain the highest economic yield, agricultural practices have been excessive in many parts of Thailand. Because of economic concern, the product outcome is becoming increasingly more desirable, with pesticides, chemical fertilizers application and intensive tillage. These come to the question whether those practices can continue the remaining of SOM.

The second question is the possibility of land use change in agricultural areas. Land use is the main features of landscape which illustrates physical development in specific area. Agricultural landscape is normally mixed between agricultural and and nonagricultural parts (Harvey, 2007). Agricultural practices, especially application rates of fertilizers and pesticides, are considered as the most important factors influencing biodiversity in agricultural landscape, revealed by Kadoya and Washitani, 2011. In this study, land use transformation in agricultural landscape which has different Town and Country Planning enforcement is pointed out. Land use sustainability considers two factors which are the aims of this research. These are 1) agricultural landscape by Landscape Transformation Index and 2) agricultural practices, focusing on fertilizer application.

The objectives of this study were to investigate the sustainability within agricultural areas with focus on both aspects, as pointed out above.

Materials and methods

Three agricultural areas of Thailand were selected, including Samut Sakorn province as industrial-based area, Samut Songkram as agricultural-based area and Nakorn Pathom province as mix-based area. All are located in the western region of Thailand (Figure 1). Characteristics of agricultural patterns, with focus on ferlilizer application, were done by interview to the farmers. Soil sample sampling was done through soil survey, only within the well-defined agricultural areas. Agricultural areas were divided into paddy field, horticulture and field crops. These are included eight-five samples within the boundary of study areas.

SOM in form of active fraction was analyzed by Walkley-Black wet combustion method (Black, 1965). Relationships of SOM and soil management practices were compared.

As land use change, land use layers of three periods supported by Department of Land Development, Thailand, were analysed using ArcGist 9.3. From the interpretation, land use categories are grouped into two main groups, namely agricultural areas and built areas. Landscape Transformation Index (LTI) (Lowicki, 2008) in equation (1) is calculated to consider the relations between agricultural areas and built areas in different periods.

$$\text{Landscape Transformation Index} = \sum \text{built area} / \sum \text{agricultural area} \quad (1)$$

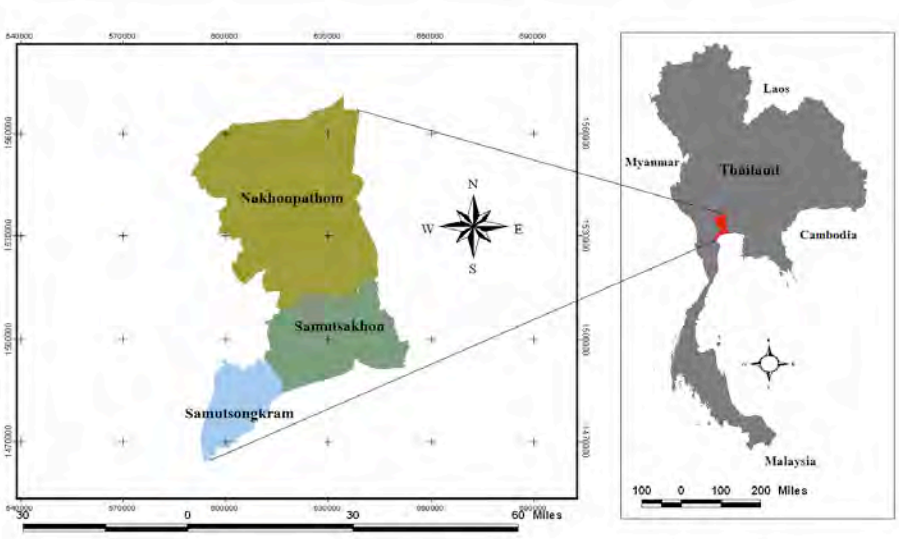

Figure 1: Study Area

Results and Discussion

The basic of soil properties in these areas is not different. Clay is the main texture and pH is in between 6-8. Soil colour is yellow-red which the munsell value is mainly showed by 10YR. Soil drainage is very poor.

Agricultural practices

According to the interview, chemical fertilizers have been highly demanded for almost samples because of the high competition to increase their yields within short period. Gardener's attitude with respect to fertilizer application is one of the causes which affect crop practices. In contrast, some small group try to establish the organic farm by using their own compost fertilizer. The case happening in Samut Songkram can emerge the challenge to promote organic farm to the other regions to sustain soil resource.

The results of pesticide practices were shown in the same ways as fertilizer. Pesticides were applied with the average of two months per time. Usually, pesticides were required for orange and rose apple trees and both are the main plants which produce high economic values in this region. In contrast with Samut Songkram, coconut is the main product and its nature has not usually been disturbed by any pests. Hence, pesticide requirement according to plant types and fruit marketing competition have an effect on the amount of pesticide used.

Resulting from interview to the farmers in Table 1, shows that chemical fertilizer is significant, especially field crops with totality. Compost and manure fertilizers are insignificant frequencies. Agricultural crops and fertilizer used show no statistical association ($P > 0.05$).

Table 1: Fertilizers application in three agricultural crops

Agricultural types	fertilizers used (unit : percentage*)		
	Compost Fertilizer	Manure Fertilizer	Chemical Fertilizer
Paddy fields	14.29	14.29	96.43
Horticulture	19.51	36.59	70.73
Field crops	6.25	18.75	100

Note*:percentage of total samples in each agricultural types

However, frequency of chemical fertilizer applied shows some difference (Table 2). It was found that the most frequency of horticulture crops is once a year whereas the others are different at twice a year. These results have significance correlation ($P < 0.05$).

Table 2: Frequency of chemical fertilizers applied

Agricultural types	Frequency (unit : times/year)		
	Once	Twice	Three times
Paddy fields	10	15	2
Horticulture	21	7	1
Field crops	6	10	Nil

Soil fertility in this research was considered by SOM content. SOM in paddy fields show the highest average levels and the minors are horticulture and field crops, respectively. On comparision, SOM according to basis soil series in the study area is higher than existing crops, as illustrated in Table 3. This is clear for paddy fields in which basis SOM is in high level (nearly 3.5%), however, the real crops are found in low level (less than 1.5%) (Department of Land Development, 2012).

Poor physical properties resulting from chemical fertilizers and intensive tillage have led to further depletion of SOM. The result shows that soil management which considerably practices for Thai gardeners' tradition is not necessary to reverse soil fertility. The questions regarding the amount of fertilizer required to obtain economic optimum yield are raised with result of this study. In point of fact, organic and clay particles can hold to nutrients in soil. Soil textures in this study area are mainly clay which cannot change its amount, organic levels can easily decrease or increase by soil performance. Many gardeners neglect this valuable resource by tilling excessively which can cause the loss of organic matter by greater removal of plant nutrients and less opportunity for nutrient cycling. Consequently, these directly affect the declining of nutrient holding capacity.

Table 3: Soil organic matter in three crop types

Crop types	Basic SOM*	Soil Organic Matter(%)	
		Average	Range
paddy field	3.4643	1.4152	0.5197-2.4502
horticulture crops	1.7538	1.1373	0.1991-1.9034
field crops	1.6400	0.6843	0.1830-0.9703

Source *Department of Land Development, Thailand

Landscape Transformation Index (LTI)

The second interested concerns the remaining of agricultural areas. Table 4 shows LTI in the periods from 2001 to 2009 of three areas. Industrial based area (Samut Sakorn) presents the highest value in all periods. Surprisingly, the index value of agriculture based area (Samut Songkram) in 2009 is prominent, comparing with the former periods. This evidence could warn us about the possibility of agricultural areas declined in the future. This concern is supported by Pearson correlations in Table 5 in which the LTI values in industrial and agricultural based are in the same direction, with correlation value 0.755.

Table 4: Landscape Transformation Index of three areas.

Years Areas	2009	2007	2001
Samut Sakorn	0.5851	0.6821	0.3049
Nakorn Pathom	0.1921	0.3544	0.2543
Samut Songkram	0.2678	0.1749	0.0608

Table 5: Pearson correlations of Landscape Transformation Index in three areas.

	Samut Sakorn	Nakorn Pathom	Samut Songkram
Samut Sakorn	1		
Nakorn Pathom	0.375	1	
Samut Songkram	0.755	-0.325	1

The ILT results in Table 6 show the change of land use from agricultural areas to urban dwelling in different four periods. It was found that horticulture crops have been rapidly changed with the highest ILT values in nearly all periods. The minors are field crops and paddy fields, respectively. The reasons are dominated by urban growth without the enforcement by Town and Land Use Planning. Many horticulture crops are situated nearby commercial and industrial areas. On contrary, paddy fields are mainly in the country sides, hence, the possibility to decrease the crop areas is lower than those happening in the other two. The average values of SOM are also high in paddy fields in which the ILT shows the lowest degree. However, the ILTs of four periods have been in the same direction (Table 7) which the highest correlated was in the years 2007 and 2009, with 0.9740 correlations.

Table 6: Index Landscape Transformation

	Index Landscape Transformation				SOM (Average)
	2009	2007	2001	1994	
Paddy field	0.4762	0.2987	0.0410	0.0335	3.4643
Field crops	0.6543	0.6635	0.0976	0.0616	1.6400
Horticulture crops	0.7114	0.9611	0.5904	0.0545	1.7538
Pearson correlation (SOM &ILT)	-0.9580	-0.8670	-0.5330	-0.9820	

Table 7: Pearson correlations of Landscape Transformation Index in four period.

	1994	2001	2007	2009
1994	1			
2001	0.3630	1		
2007	0.7580	0.8830	1	
2009	0.8870	0.7530	0.9740	1

Conclusion

Results of this study could answer two points of land use sustainability. The first is that characteristic change of land use from green to built areas shows the highest in industrial based area and the lowest is found in mix-based area. Agriculture based area is significantly found rapidly transformation to built area in more or less rate with industrial based area. The second is that the characteristics of fertilizer application in three agricultural cropping system. Chemical fertilizers have been heavily applied, with different frequencies in each group. To achieve the target of land use sustainability, built-up development in green areas together with the tradition of agricultural patterns is the main factors which should be concerned. There was a clear need of greater sustainable management. Basic agriculture system can allow the limited removal of soil nutrients since they can return the nutrients back to the land. Long term management is considerably required.

ACKNOWLEDGMENT

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Planning for the Desirable Land Uses in Peri-Urban Landscapes: Application of a Spatial Concept for Territorial Sustainability

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Abstract:

Increasing the sustainability of multiple-use landscapes should be the main goal for strategic planning. On the surroundings of conventional urban regions, old (agri)cultural landscapes around the world are appropriate areas where to analyze peri-urban land use optimization and change, for planning purposes.

The quantification of existing land use differentials against (normative) desirable distributions may give effective tools for the macro-diagnose the sustainability and resilience of the landscape. On the other hand, the optimization of landscape pattern is subject to debate, arising in part from prevention and diverse definition of resilience optimization (engineering vs. ecological resilience). It is a question equally involving the meaning and values dimension (both at social and individual level) inside such old and contemporary cultural landscapes. Specification on the context and purpose of the analysis eventually may avoid such caveats.

The use of quantified guidelines from spatial landscape ecology concepts (normative approach, on functional composition and configuration mosaic patterns) may provide this way one of the possible tools inside the heterogeneous collection of methods required, aiming at the application of sustainable landscape and regional planning strategies.

Introduction

In the research, we present an application of a spatial concept as a tool in planning processes, aiming to detect desirable land use distributions in peri-urban landscapes -the ones in the fringe of metropolitan areas, inside urban regions and megalopolis. Through comparative analysis in different world megalopolis and bioclimatic regions (e.g. Barcelona region, North East megalopolis US, Beijing region), we look for an integrative approach to strategic planning of such changing landscapes.

We argue with this kind of functional approach we can integrate most significant part of the complexity of the landscape as a system (both the socio-economic and environmental side, as well the social values and meaning inside cultural landscapes): based in the non-linear dynamics paradigm, aim at natural and human processes optimization and increasing systems resilience. As a thought experiment, it is in the quest for the unstable balance, between ecosystem services and planned development.

As a context, for first time in history there are nowadays more dwellers living in urban areas than not, often in a characteristic low-density suburban sprawl; a land where the rural-urban landscape fringe becomes messy, often resulting in a mix of non-structured and waste spaces.

The goal of strategic planning should be addressing this 'missing link‘ on still non-urban landscapes, where such unresolved structures result (Girot, 2000). Positive remedial proposals envisage the integration of socio-economic and historical factors, on the explanation of actual and desirable spatial configurations. Especially, the meaning of agricultural activities in urban regions has to be explicitly considered in the mix, important as it is for the regional ecological footprint, strategic supply and the increase of regional resilience against alterations.

The analytic tools required to understand and manage land use trends will need to approach the concept of multi-functionality, itself a balance and function of scale. Human settlement and activities are the main drivers of land use change, so it is required to manage the tension between providing human and ecological services and planned development, in a dynamic and unstable equilibrium.

We need to design approaches standing for consistency as well: starting with data collection, we may design studies to allow contrasts from comparison, guided by a conceptual framework accounting for interactions at multiple scales .

On the question of how fast is Biodiversity disappearing, no precise estimates available because the number of species is not known, the biodiversity reduction is a function of size and isolation of fragments and species ranges are not well known. We know the current biodiversity decline is 1000 to 10000 times faster than any other time in geological history. The world is shrinking: according to UN projections (UN 2005), in 2025 population will be around 8 billion, half of them living in water-stressed river basins. We are already using nature more rapidly than it can regenerate (in a ratio 1:1,2 planets).

We know as well biodiversity reduction is a function of size and isolation, and that a tenfold increase in area results in a doubling of species. This leads to the concept of interrelation of species and area (Wilson & Peter, 1988).

Spatial optimization in cultural landscapes

When we ask 'Why societies are no more able of producing landscapes of ecological and aesthetic integrity?', we revolve around an old concern, since industrialization began: the actual failure to optimize the new urban patterns in historic cultural landscapes is in fact the failure on the old perceived lack of integration between human and natural subsystems. As a reaction to this lack, in the first half of the XIX Century emerged landscape tourism in New England (US) and industrialized nations. Nowadays, tourism and recreation play an ambivalent (but major) role in cultural landscapes.

For successful strategic planning, we are told we have equally to shape existing community values (Gunder 2005). Far from objective (and as a questionable goal itself), it has to be declared which is the purpose of intended optimization processes, inside the landscape. The proactive planning of the desirable landscape mosaic relates in fact to social perceptions (Walker, 2005; p.84), and even as an intuition is measurable indeed.

How can we define then the problem and required methods to check our spatial intuitions? Although it might not be possible to formulate one universal method, analytical problem-solving approaches, at the end, will share same spatial and temporal issues: about the scale, resolution (grain), and boundaries and gradients definition. And stating the goal of sustainable territorial design, proactive approaches may be helpful tools in that direction.

According to Panarchy theory as well (Holling, 2001), resilience is the key aspect on definition for sustainable territorial strategies: inside socio-environmental systems, non-linear, alternating stable states create normal journeys that maintain the diversity of species, spatial patterns and genetic attributes (the basis of resilience)

This is why the search for an optimal state to be maintained in time usually leads to a large loss of ecological resilience, manifest in the irreversibility of processes (regime change) inside coupled socio-environmental systems. Such models are defined as incremental and linear. But optimization does not work as a best practice model because response to shocks and disturbances depends on context, connections across scales and current state of the system.

Current best practices (business as usual) result in a cascade of unforeseen problems. Ignorance and misunderstanding play a role; but as a matter of fact there are perverse incentives working against biodiversity and resilience schemes. This usually happens when the processes of optimization (either agricultural production, timber harvest, or species protection in reserves) take into account just a few components of existing socio-environmental systems.

Then we have to question in fact if uncertainty in nature can be replaced with human control certainty: even if socio-economic systems can flourish following ecological stabilization and economic opportunity interactions between slow-moving and fast-moving processes, on the long term the collapse is certain. By focusing on optimization target variables, the gradual changes produced on other system components are overlooked. Then, if we acknowledge this, the era of ecosystems management via increases in efficiency may be over (Peterson 2002).

There is in fact not such a thing as a sustainable 'optimal' state: complex systems are continually adapting to change. In the ruling paradigm we optimize components of a system in isolation; this is inadequate to deal with the dynamic complexity of the real world: efficiency by itself is not the problem, but applied to a narrow range of values and a particular set of interests eventually sets the system in a trajectory that, due to its complex nature, leads to unwanted outcomes (Walter & Salt 2006).

Engineering optimization in fact promotes the simplification of values: demotes life support systems, as the regenerative and cleansing services provided ('ecosystem services'), and discounts the values placed on beauty or existence of species. Equally, it distorts the time horizons of the main ecological processes, as reduces the time horizons to a couple of decades –the limits of time horizon for most commercial investments. This way, the values that do not have property rights, or are public, or not marketed do not generate wealth and gain little support, even if they involve critical ecosystems services. The paradox of efficiency and optimization is that with the increase in efficiency, the result is major inefficiencies in the way we generate values for society (Walter & Salt, 2006).

From non-linear systems dynamics paradigm, we are told landscapes may spatially self-organize (Cumming, 2011). This implies in such coupled

socio-environmental systems, social values play a significant role in the maintenance of the current spatial pattern. Is it detectable? If so, the effect of community values -with the goal of place making- on landscape spatial distribution may be analyzed: we can ask if values (collective and individual) can be possibly detected in spatial arrangements of cultural landscapes.

Operatively, when looking for resilience optimization we are in fact creating space in a shrinking world. In their measurement, we have to answer: Are the key variables approaching a threshold? What are the dynamics of this system? What are the connections between scales? As possible options then, we may detect ecological land use thresholds and regime change effects, as well the ones due to administrative boundary effects. Equally, the characterization and quantification of the impacts of new drivers, dynamics of change (break on modularity and multiple scales) provides another complementary view of the actual processes in the landscapes. Further questions on values and global processes refer to the role of recreation and tourism –an important part of the equation.

References for historical cultural landscapes and place-making treatment

The key is then enhancing the resilience of socio-ecological systems, not just optimizing isolated components. In this sense, the historic approach of traditional societies in East Asia (the relation between man and nature) is historically much more integrative: for example in the case of Feng-Shui landscape, or the multifunctional Satoyama landscapes in Japan, or the 'nested' villages (*Tong*) in Corea.

The landscape design model or representation of Feng-shui, as a fractality of 'boxes-within-boxes', provided in fact the 'live-within' approach, in which a hierarchical systemic or socioecological vision, fostering the psychological requirements of place identity and the 'process of dwelling' (Yu, 1994). The attached meaning of house design symbolized family expectations for its future: in order to reflect cultural character, fit the house into its social and historical background, and provide symbolism shared by its dwellers.

As an historical precedent of spatial optimization too, in Barcelona in the mid XIX century, the pioneer urbanist Ildefons Cerda and his egalitarian "Social philosophy" declared goal to improve urban population living conditions at the same time than of creating place-making -with the motto 'urbanize the rural, ruralize the urban' (Ildefons Cerda, 1856).

Nowadays, the urban 'tsunami' requires the redefinition of the social values and design of the 'lived landscape' at a higher domain, that of the functional region or mega-region (the context for cultural landscapes). We might

extrapolate now to a regional system this historical local place-making process, as a designed strategy. A main strategic issue still is the amount of farmland and the multifunctional mix of land uses, providing resilience and diminishing the ecological footprint -a question as well linked to the diverse perceptions or meaning.

We need to foster in fact the ecological resilience as well as the self-organized flexibility needed to cope innovate and adapt. One option is to plan the designed landscapes and ecologies required, questioning optimization solutions limiting the range of available options to the narrower engineering resilience. As alternative, in the analysis we can search for partitioning of diversity, phenomena non-randomly associated with discontinuous structure, key clumps, discontinuities and thresholds generating resilience. Options include checking results against ecological thresholds (table 1), seen in itself as spatial concepts.

Part of the problem arises when we treat an ecosystem as a closed, spatially bounded biotic system. Human alteration and impacts are pervasive, but not part of ecosystem processes itself. We have to work then the coupled socio-environmental systems as processes at landscape and regional level, instead.

Operatively, we are to make a territorial synthesis of multifunctional uses, an ordered choice maintaining the strategic services. As physical units, we will need to work with the watershed sub-basins disctinctive landscapes, mainly characterized by topography and hydrologic process, and the repeated land-use configuration (eg. alluvial plains, foothills, mid-mountain). Particular configurations of topography, vegetation cover, land use and settlement patterns define some coherence of natural and cultural processes and activities.

Spatial concepts

By definition, spatial concepts are strategies used to help build systemic solutions to complex problems (Ahern, 2005); usually they start by addressing a perceived ‘lack’ or malfunction in territorial systems. They can be seen as extensions of thought experiments: a multiplicity of competing accounts of the same settings is possible. This way, the context and intent of each narrative are important elements in the evaluation process.

Ian McHarg’s (1969) *ecosophy* or regulatory approach (a layered planning sequence), pioneered the view of natural systems processes as social values in itself (as ecosystem services): land, air and water resources are indispensable to life, and thus recognition of these as social values define in turn the character of a place. Inferences then can be drawn regarding utilization to ensure optimum use and enhancement of social values –which constitute its

intrinsic suitability: each place is inherently suitable for a multiplicity of human uses, and remains within society to make the choice.

Application on landscape analysis

Nowadays this focus on optimizing landscape spatial pattern and resilience still generate novel conceptual approaches: for example, "Open historicity" frameworks allow to locate a specific 'mosaic' inside a continuum of spatial dynamic patterns (by the "temporal convening of the spatial"; Massey, 1999), defined along a contemporary axis on entropy or spatial heterogeneity (figure 1). It is possible to define different narratives, as part of the required collection of heterogeneous experiments on landscape pattern (O'Sullivan, 2004; Carpenter et al 2009).

In sum, as long as we are aware that there is no optimal land architecture that works 'for everything' (Turner, 2010), and that spatial heterogeneity may interact non-linearly with the existing drivers, we may formulate the specific methods and tools for strategic planning required in such increasingly altered landscapes. With the aim to achieve the most desirable landscape distributions, the AWO as a thought experiment synthesizes diverse evidence and consolidated knowledge -as well author's spatial intuitions- about structure, function and change of the landscape domain.

By our development on the qualitative guidelines of the principle (table 2), through joint optimization -maximization in size variance and land use diversity- were obtained differentials (percentages) of 'actual' versus 'desirable' aggregated land uses distribution on landscape pattern (a functional definition, according to natural gradient: natural vegetation, agricultural, urban). It was constitutive in fact of a territorial macrodiagnostic, against which allow contrast different spatial patterns of culturally unique landscapes, and possible scenarios.

This synthetic view for compositional optimization is seen in fact as a pre-condition for configuration designs -as its contextualization. A situation in which the matrix and large spaces are compositionally weak may lead to an increase in entropy: decreasing variance in size typologies and an increase of internal land use diversity. The amount of the medium size patches on the other hand might be seen as an early-warning signal of a critical transition in landscape properties (fig.2) –a shift in scale to the 'complex nature of the global' (O'Sullivan et al 2006, p.614).

For strategic planning, when the decrease of matrix space and the increase of medium spaces typology are the case, configuration design would be crucial to reconnect the landscape patches (offensive scenarios). The differentiation of

such scenarios with quantifiable thresholds seemed a helpful clue in the design of planning strategies

Conclusions

From compositional analysis of land-use pattern (typologies) and thresholds in size, we developed a narrative or plot of the comparative landscape situation. As a conclusion, we may value this way the landscape services provided by existing, desirable and expected mosaic configurations (scenarios), seeking for the optimum level for multiple functions (not the maximum or minimum level for anyone). We need to focus in the balance which configures the slow moving compositional variables, entraining the fast-moving ones.

This way, no more data means better model. What are urgently required in fact are the mechanistic (functional) explanations of the processes at landscape and regional levels. For future research, we question if AWO landscape pattern is a systemic equivalent of network patterns on natural Systems, with which to address strategic resilience optimization in the landscape within a universal framework.

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Tables and figures

Table 1. Thresholds in ecosystem management and conservation

Percolation thresholds	**Old growth forest**	**Higher bird diversity**	**Fish communities health**	**Impervious watershed**
When 40% LUC, configuration disconnected	>100 ha. patch	100 ha. units> 30% total patches	50% land in watershed as agricultural	10-15% of total area

Table 2. The spatial criteria of the Aggregate-with-Outliers spatial concept

1.	Existence of large natural vegetation patches
2.	Variance of the grain size of patches
3.	More than one natural or agricultural large aggregated space
4.	Existence of small spaces (Outliers)
5.	Outliers located along and near the edges of large spaces
6.	Presence of small natural vegetation patches even in developed areas
7.	Existence of corridors (natural and human), linking both natural vegetation patches, and developed areas

Figure 1. Diagram of heterogeneity gradient (aggregated land uses) in the landscape: Homogeneous / AWO heterogeneity / Heterogeneous sprawl.

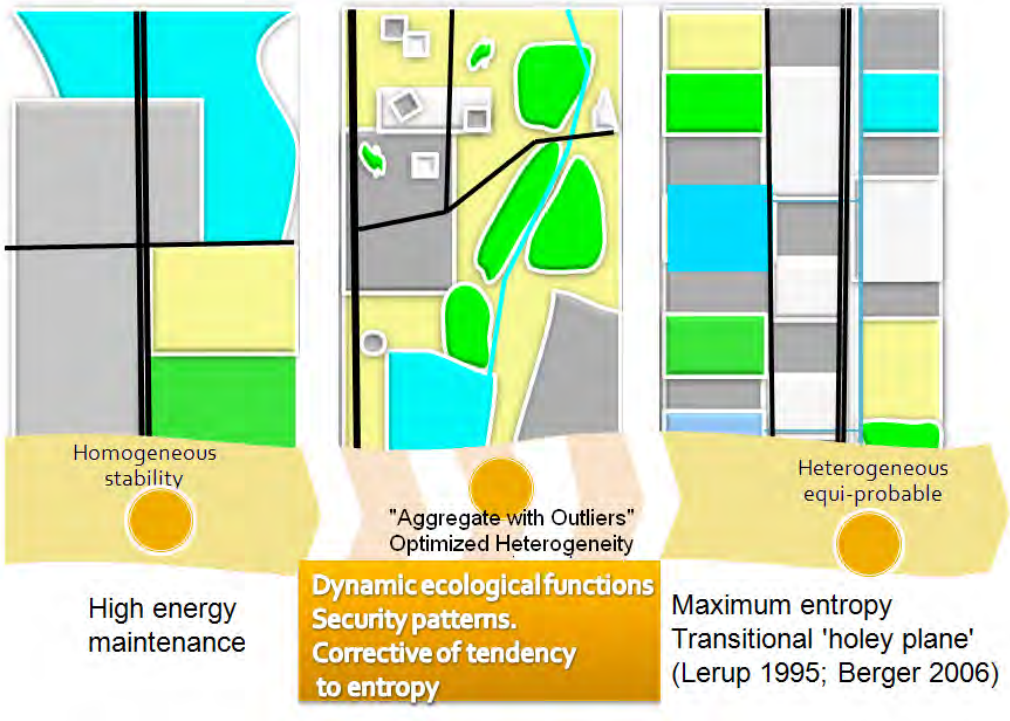
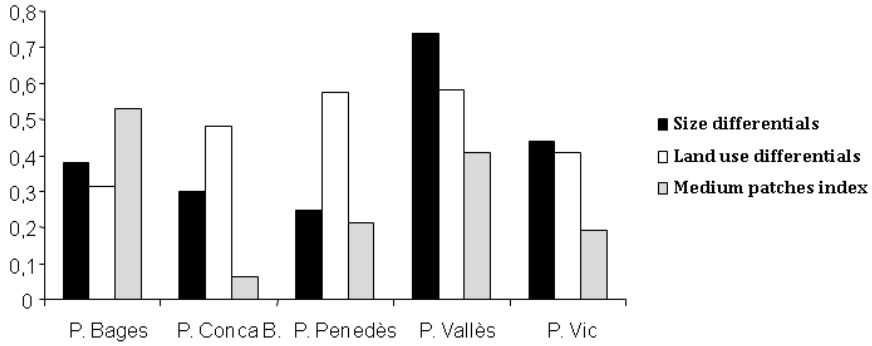


Figure 2. Differentials for each landscape (proportion of size, land use and medium spaces index).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P. Conca B.
P. Penedès
P. Vallès
P. Vic
Size differentials
Land use differentials
Medium patches index

Development of Electrical Generation System for Small Scale Pig Farm in Thailand Rural Area

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The Asian Conference on Sustainability, Energy and the Environment

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Abstract:

In Thailand total diary pig in farm is estimated to be 5.4 million, mostly 1,574 farms is medium scale, which are approximately 2.3 million of pigs and 140 large farms were 1.5 million of pigs. The wastewater generated in the farm cause significant environmental problems. Biogas technology has been studied and applied in small, medium, and large scale projects. Operated as small businesses or cooperatives, there was several ways biogas technology can benefit a community. This research was presented a development of electrical generation system for small scale pig farm. Consider at 50 m3 of fixed dome. Biogas used to be the fuel for used gasoline engine 1500 cc. to drive induction generator, 5.5 kW, 380 V, 4 pole, with grid connection. From the experiment, it had found that the relationship between speed of induction generator, electrical power supply to grid, for find optimizing point of induction generator work done. The experiment supply electrical power to grid and comparison of electrical cost with and without electrical generation system. The result showed that 70 % of electrical cost was saved when the system was connected with the electrical generation system. This system have payback period at 2nd year.

1.Introduction

Renewable Energy is energy derived from resources that are regenerative or for all practical purposes non-depleting beside environmentally benign. By these qualities, renewable energy sources are fundamentally different from fossil fuels. Mankind's traditional uses of wind, water, and solar energy and geothermal are Renewable Energy is energy derived from resources that are regenerative or for all practical purposes non-depleting beside environmentally benign. By these qualities, renewable energy sources are fundamentally different from fossil fuels. Mankind's traditional uses of wind, water, and solar energy and geothermal are widespread in developed and developing countries; but the mass production of energy using renewable energy sources has become more commonplace recently, reflecting the major threats of climate change, depletion of fossil fuels, and the environmental, social and political risks of fossil fuels. Consequently, many countries promote renewable energies through tax incentives and subsidies. The role of new and renewable energy has been assuming increasing significance in recent times with the growing concern for the country's energy security. Vice versa fraction remains of consequence from agricultural industries and garbage from human and animal productivity can be used as a renewable energy source has. This will help maintain energy resources from nature as not to decrease. And maintain the balance of the world.

Since the 1940's and World War II. However, only since becoming a category of appropriate technology (a community development concept of the 1970's) have biogas systems enjoyed widespread success and failure. Why should biogas systems contribute to the community development process in both the developed and developing worlds?

This research was presented a development of electrical generation system for small scale pig farm in Thailand rural area. Biogas used to be the fuel for gasoline engine 1500 cc. to drive induction generator. Small scale system the induction generator was optimization. Because, low cost and easy to maintenance than synchronous generator.

2 Theory

2.1 Biogas

Biogas produced in AD-plants or landfill sites is primarily composed of methane (CH_4) and carbon dioxide (CO_2) with smaller amounts of hydrogen sulphide (H_2S) and ammonia (NH_3). Trace amounts of hydrogen (H_2), nitrogen (N_2), carbon monoxide (CO), saturated or halogenated carbohydrates and oxygen (O_2) are occasionally present in the biogas. Usually, the mixed gas is saturated with water vapors and may contain dust particles and siloxanes.

Table 1. Biogas Components

Type	Quantity
Methane (CH_4)	50 – 70 %
Carbon dioxide (CO_2)	25 – 35 %
Nitrogen (N_2)	2 – 7 %
Hydrogen (H_2)	1 – 5 %
Carbon monoxide (CO)	Slightly
Hydrogen sulphide (H_2S)	Slightly
Other	Slightly

The characteristics of biogas are somewhere in-between town gas (deriving from cracking of cokes) and natural gas. The energy content is defined by the concentration of methane. 10 % of CH_4 in the dry gas correspond to approx. one kWh per m^3.

2.2 Mechanism of Extraction

The fermentation process for formation of methane from cellulosic material through the agency of a group of organisms belonging to the family 'Methano bacteriaceae' is a complex biological and chemical process involving three main stages.

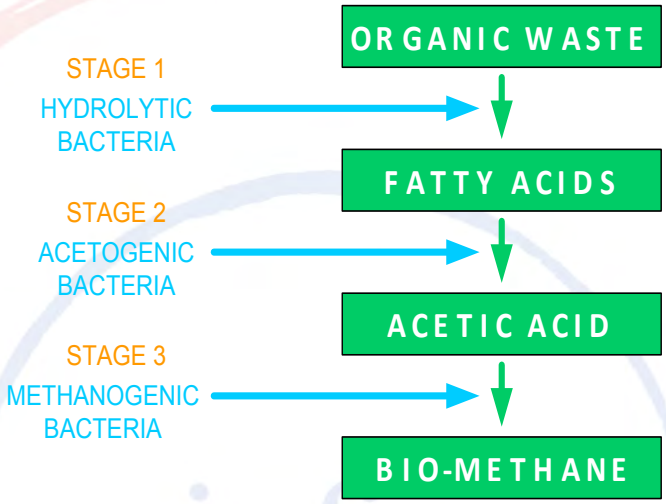

Fig. 1 Stage of mechanism of extraction

-Stage 1 Hydrolysis Process

Bacteria break down complex organic materials, such as carbohydrates and chain molecules, fruit acid material, protein and fats. The disintegration produces acetic acid, lactic acid, botanic acid, methanol, ethanol and butanol, as well as carbon dioxide, hydrogen, H_2S and other non-organic materials. In this stage the chief micro-organism are ones that break down polymers, fats, proteins and fruit acids, and the main action is the butanoic fermentation of polymer

-Stage 2. Actogenesis Process

In this stage, bacteria produce acetic acid and produced hydrogen and carbon dioxide population in to biogas.

-Stage 3. Methanogensis Process

The simple organic materials and carbon dioxide that have been produced are either oxidized or reduced to methane by micro-organisms, the chief ones being the methane producing micro-organisms of which there are many varieties.

This stage may be represented by the following overall reactions:

$$(C_6H_{10}O_5)n + nH_2O \longrightarrow 3nCH_4 + 3nCO_2 + \text{heat}$$

Individual reactions include:

i. Acid breakdown into methane.

$$2C_3H_7COOH + H_2O \longrightarrow 5CH_4 + 3CO_2$$

ii. Oxidation of ethanol by CO_2 to produce methane and acetic acid.

$$2C_3CH_2OH + CO_2 \longrightarrow 2CH_3COOH + CH_4$$

iii. Reduction with hydrogen of carbon dioxide to produce methane.

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$$

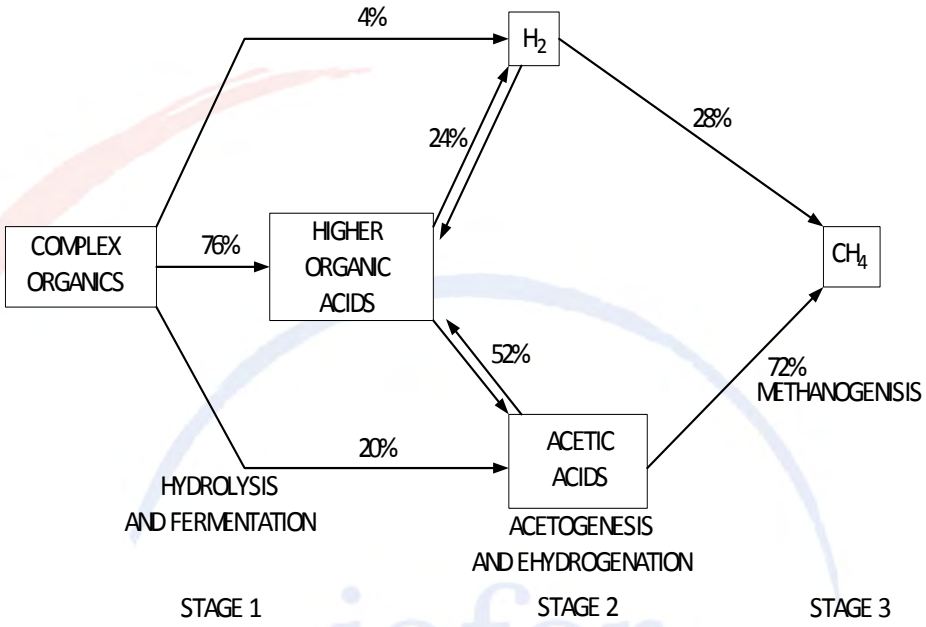

Fig. 2 Individual reactions include

A careful balance should be maintained between the two stages. If the first stage proceeds at a much higher rate than the second, acid will accumulate and inhibit the fermentation in the second stage, slow it down and actually stop it.

2.3 Fixed dome digester

Biogas is made by fermenting organic waste in a biogas digester**.** The size of a digester can vary from a small household system to a large commercial plant of several thousand cubic meters. Simple biogas digester designs have been developed; the Chinese fixed dome digester and the Indian floating cover biogas digester (shown in Fig. 3). The digestion process is the same in both digesters but the gas collection method is different in each. In the floating cover type, the water sealed cover of the digester rises as gas is produced and acts as a storage chamber, whereas the fixed dome type has a lower gas storage capacity and requires good sealing if gas leakage is to be prevented. Both have been designed for use with animal waste or dung. The waste is fed into the digester via the inlet pipe and undergoes digestion in the digestion chamber. The temperature of the process is quite important because methane-producing bacteria do their work best at temperatures between 30 – 40^{o}C or 50 – 60^{o}C. It takes from 2 to 8 weeks to digest a load of waste, depending on the temperature. The left-over slurry is removed at the outlet for use as a fertilize

Fig. 3 Fixed dome digester

2.4 Methane Production

- Air tightness: Breakdown of organic materials in the presence of oxygen produces CO_2 and in absence of it produces methane. Thus it is crucial to have the Biogas pit airtight and watertight.

- Temperature: Temperature for fermentation will greatly affect biogas production. Depending on prevailing conditions methane can be produced within a fairly wide range of temperatures. However, the micro-organisms which take part in methane fermentation have the optimum activity at 30°C-40°C. The production of biogas is fastest during summer and it decreases at lower temperatures during winter. Also methanogenic micro-organisms are very sensitive to temperature changes a sudden change exceeding 3°C will affect production, therefore one must en sure relative stability of temperature.

- pH: The micro-organism require a neutral or mildly alkaline environment will be detriment a too acidic or too alkaline environment will be detrimental. Ideal pH value is between 7.0– 8.0 but can go up or down by further 0.5. The pH value depends on the ratio of acidity and alkalinity and the carbon dioxide content in the biogas digester, the determining factor being the density of the acids. For the normal process of fermentation, the concentration of volatile acid measured by acetic acid should be below 2000 parts per million, too high a concentration will greatly inhibit the action of the methanogenic micro-organisms.

- Solid Contents: Suitable solid contents of raw materials are 7-9%. Dilution should be in the ratio of 4:5 or in equal proportion.

- C/N ratio: A specific ratio of carbon to nitrogen must be maintained between 25:1 and 30:1. The ratio varies for different raw materials.

- Water Content: This should be about 90% of the weight of the total contents. With too much water the rate of production per unit volume in the pit will fall, preventing optimum use of the digester. If the water content is too low, acetic acid will accumulate, inhibiting the fermentation process and hence production and also thick scum will be formed on the surface. The water content differs according to the raw material used for fermentation.

- Nature of organic materials: Materials rich in cellulose and hemi-cellulose with sufficient protenaceous substance produce more gas. Complex polysaccharides are more favorable for methane formation while only protenacous materials produce little quantity of gas. Lignin as such does not contribute of the gas production.

- Supplementary nutrients: In case of pig dung, as if contain all the nutrients need by organisms for the production of methane there is no necessity for addition of nutrients to it.

- Reaction period: Under optimum conditions 80-90% of total gas production of is obtained within a period 3-4 weeks. Size of the fermentation tank also decides the reaction period.

- Gas output: The exact amount of gas produced depends on various factors. In the first instance the amounts of animal droppings vary from animal to animal, feed given to animal, season of year,

whether the animal is stable bound or a free-grazing type etc. The following table gives an idea of the amount of gas available from different types of raw material. The figures however are likely to vary very widely

Table 2. Production of biogas from different types of raw material

Material	Amount of gas (m^3/kg of fresh material)	
	Winter	Summer
Cattle dung	0.036	0.092
Night-soil	-	0.04
Pig dung	0.07	0.10
Poultry droppings	0.07	0.16

2.4 Induction Generators

The technology of induction generator is based on the relatively mature electric motor technology. Induction motors are perhaps the most common types of electric motors used throughout the industry. Early developments in induction generators were made using fixed capacitors for excitation, since suitable active power devices were not available. This resulted in unstable power output since the excitation could not be adjusted as the load or speed deviated from the nominal values. This approach became possible only where a large power system with infinite bus was available, such as in a utility power system. In this case the excitation was provided from the infinite bus. With the availability of high power switching devices, induction generator can be provided with adjustable excitation and operate in isolation in a stable manner with appropriate controls.

Induction generator also has two electromagnetic components: the rotating magnetic field constructed using high conductivity, high strength bars located in a slotted iron core to form a squirrel cage; and the stationary armature similar to the one described in the previous paragraph for PM technology. Figure 4 shows the construction of a typical induction generator in a cross sectional view.

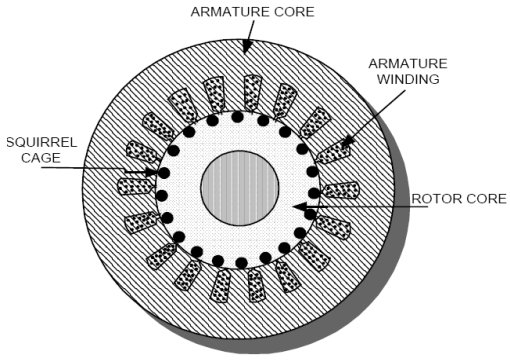

Fig.4 Squirrel cage induction generator cross-sectional view

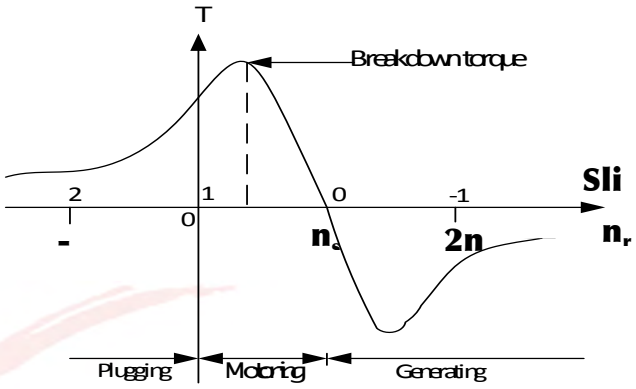

Fig. 5 Characteristic of torque and speed

2.5 Grid connected Induction Generator

Induction machine connected to grid system induction machine was operating as motor. Used prime mover driven induction machine have rotor speed than synchronous speed ($N_r > N_s$) induction machine operating as generator. Real power supplied to grid system and grid system supplied active power to induction machine used to excited electromagnetic field. Output voltage and output frequency same as grid system

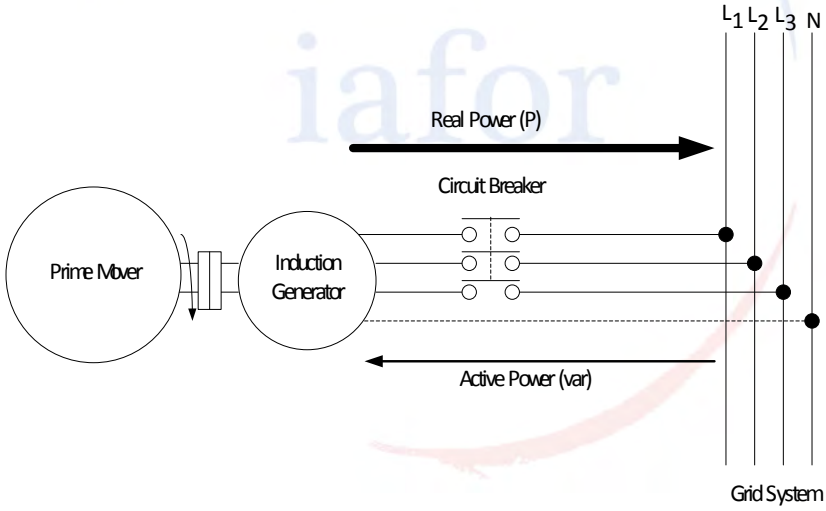

Fig. 6 Grid connection

2.6 Stationary engines (CHP)

Biogas can be used for all applications designed for natural gas. Not all gas appliances require the same gas standards. There is a considerable difference between the requirements of stationary biogas applications and fuel gas or pipeline quality. The utilization of biogas in internal combustion engines is a long established and extremely reliable technology. Thousands of engines are operated on sewage works, landfill sites and biogas installations. The engine sizes range from 45kW (which corresponds to approximate 12 kW_{el}) on small farms up to several MW on large scale landfill sites. Gas engines do have comparable requirements for gas quality as boilers except that the H_2S should be lower to guarantee a reasonable operation time of the engine. Otto engines designed to run on petrol are far more susceptible to hydrogen sulphide than the more robust diesel engines. For large scale applications (> 60 kW_{el}) diesel engines are therefore standard. Occasionally, organic silica compounds in the gas can create abrasive problems. If so, they should be removed. A diesel engine

can be rebuilt into a spark ignited gas engine or a dual fuel engine where approx. 8-10 % of diesels are injected for ignition. Both types of engines are often applied. The dual fuel engine has higher electricity efficiency. The requirements for the gas upgrading are the same; small CHP (< 45 kW_{el})

3. Experimental Setup

This experimental used two type of gasoline engine 1500 cc. to drive induction generator, 5.5 kW, 380 V, 4 pole, with grid connection**.** Compare efficiency of engine A with engine B. Engine A was flue injection. Engine B was carburetor.

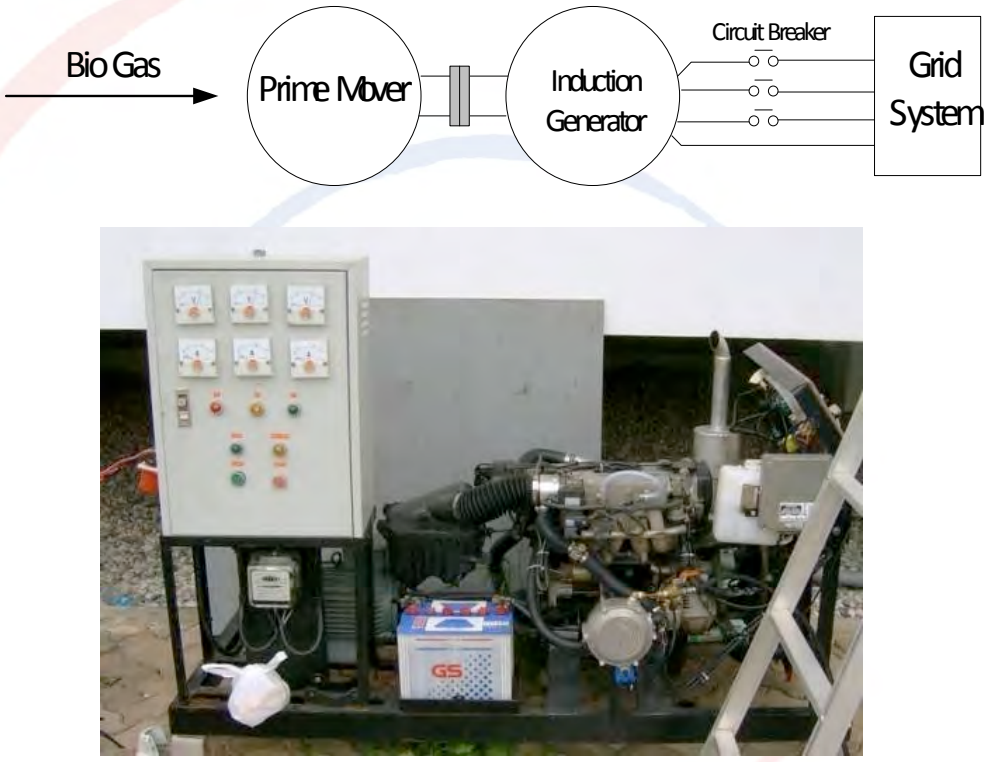

Fig. 7 Experimental setup of small scale pig farm

Component of biogas for test system: Methane (CH_4) 70.4 %, Carbon dioxide (CO_2) 24.6 %, Oxygen (O_2) 0.3 %, Other 4.7 %

4. Experimental Result

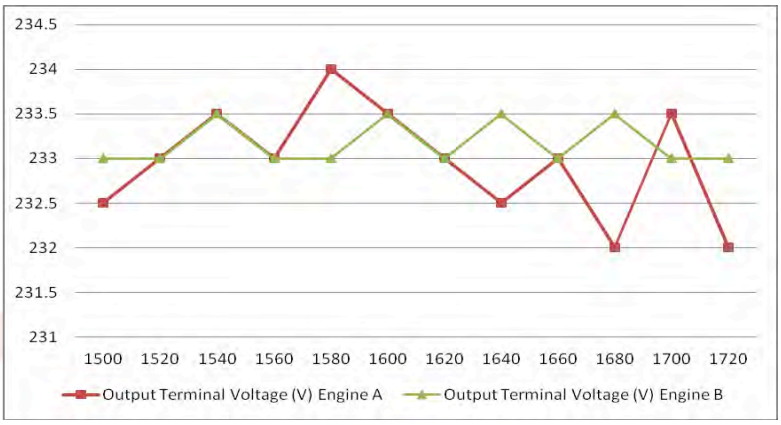

Fig. 8 Speed and output voltage of induction generator

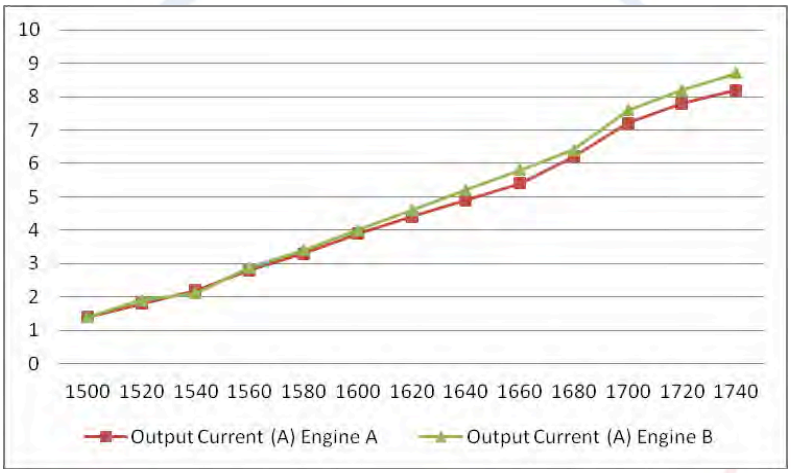

Fig. 9 Speed and output current of induction generator

There results in fig. 8, fig. 9 show speed of induction generator, output voltage and output current. Induction generator supplied power to grid is 1500-1740 rpm.

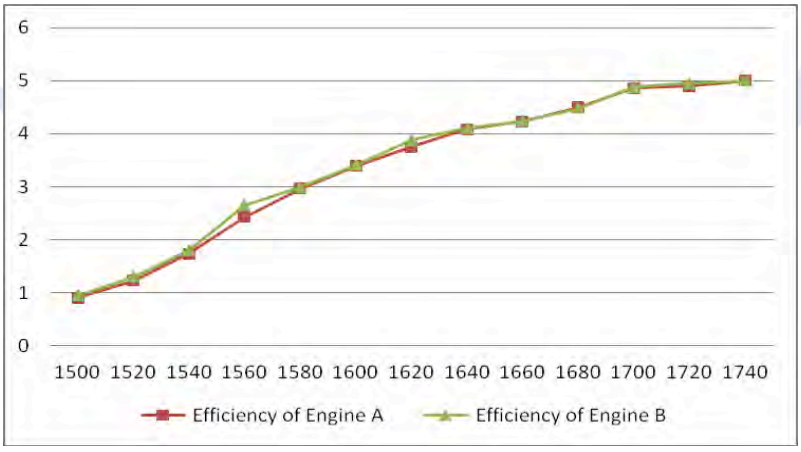

Fig. 10 Speed and output power of induction generator

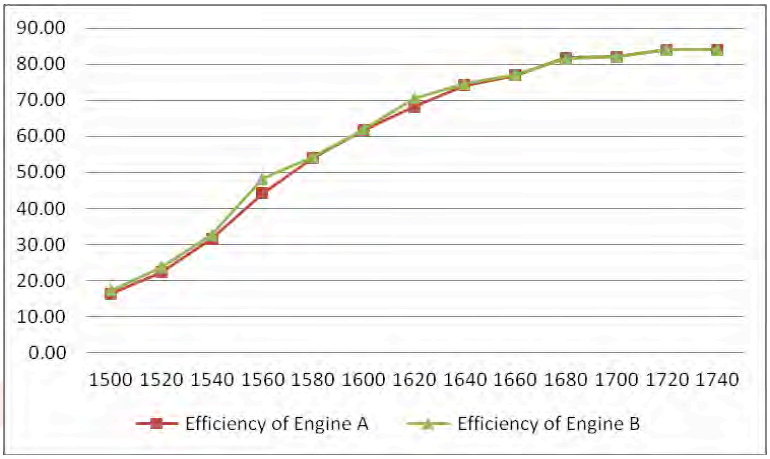

Fig. 11 Speed and efficiency of induction generator

There result in fig.10 at 1740 rpm. induction generator supplied output power at rate power 5 kW. Find optimization point for operate this system

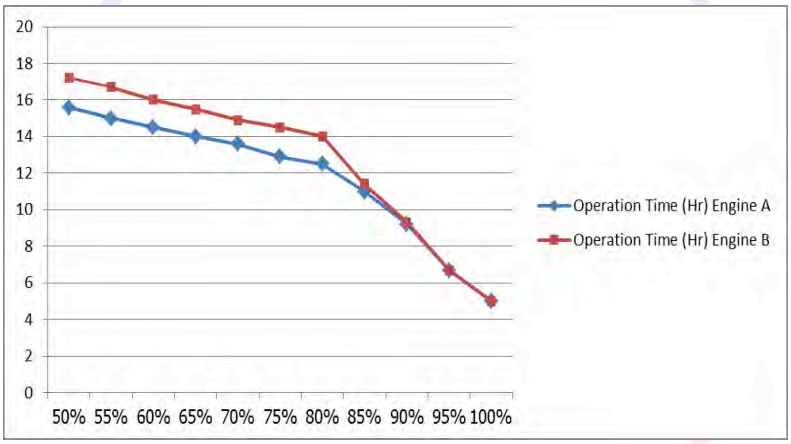

Fig. 12 Efficiency and time period of induction generator

From the result in fig.12 optimization of time period is 14 hour per day and 80 % efficiency of induction generator with engine A and optimization of time period is 16 hour per day and 80 % efficiency of induction generator with engine B. Since was carburetor engine suitably to biogas.

5. Economic Analysis

Induction generator has 1660 rpm. of speed and output power supplied at 4.5 kW. Biogas flow rate 0.00082 m^3/s. One cubic meter of biogas has energy 21.5 MJ.

$$P_{in} = 21.5x0.00082$$
$$= 0.01736\ MJ/s$$
$$= 17.63\ kJ/s$$
$$= 17.63\ kW$$

Total efficiency of system from biogas to electrical power

$$\eta = \frac{P_{out}}{P_{in}} x100$$
$$= \frac{4.5kW}{17.63kW} x100$$
$$= 25.52\ \%$$

Output power is 4.5 kW x 12 hour
= 54 kW-h per day and 1620 kW-h per month
unit price = 3.5 Baht/kW-h, Ft = 0.5683 Baht/kW-h

-Electrical Power Price = 5,827 Baht/Month
- Ft = 920 Baht/Month
- Vat = 475.44 Baht/Month

Total save cost per month = 7,267.44 Baht/Month
Total save cost per year = 87,209.28 Baht/Month

Installation cost
- 50 m^3 Digester cost = 86,000 Baht
- Electrical generation system = 34,000 Baht
- Total installation cost = 120,000 Baht
- Maintenances cost = 20,000 Baht/Year

Interest rate for SME at 5% per year
Net present value present by

$$NPV = TIC - \sum_{t=0}^{n} \left[\frac{T_0}{(1+i)^t} \right]$$

TIC = *Total installation cost*
T_0 = *Total Cost in every year*
i = *Interest rate*
t = *Number of year*

Payback period present by

$$\sum_{t=1}^{n} R_t \geq TIC$$

R_t = *Total receive cost*

Table 3. Economic analysis

Year	income	expense	Total	Net Present Value
0	0	120,000	-120,000	-120,000
1	87,209.28	20,000	64,008.84	-55,991.16
2	87,209.28	20,000	60,960.8	4,969.64

$R_t = 64,008.84 + 60,960.8 = 124,969.64$ *Baht*

$$R_t > TIC$$

6. Conclusion

System proposed was saving electricity cost at 70% in every month and payback period in 2nd year. If develop this system to high efficiency, this system almost important to community energy. Because, this solving of energy crisis and environment problem.

Acknowledgement

The author wishes to thank for PANOMPORN FARM support to test area for this research and Faculty of Industrial Technology, Pibulsongkram Rajabhat University support for measurement and testing. The author also thanks the reviewers for their constructive comments and useful suggestions which have helped us enhance the quality of the manuscript.

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Catalyst Preparation by Addition of K and Na on Zeolite NaX for Transesterification of Jatropha Seed Oil

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Abstract:

This work involved preparation, characterization of potassium (K) and sodium (Na) loaded on zeolite NaX and testing for transesterification of Jatropha seed oil. The catalysts with 4, 8, 12 and 16 wt% of K and Na were prepared by impregnation with acetate buffer (B) solution of potassium or sodium (producing K/NaX-B and Na/NaX-B) and just acetate (A) solutions (producing K/NaX-A and Na/NaX-A). Impregnation of the zeolite by both precursor solutions did not destroy the NaX structure but there were decreases in surface area and micropore volume with increasing K and Na loading. With different metal loading, the catalyst basic strength and the number of basic sites were increased from that of the NaX and the catalytic activity for biodiesel production was increased. With 16:1 of methanol:oil molar ratio at 65 °C in transesterification of the Jatropha seed oil, the best catalyst was K/NaX-B with 16 wt% Na loading. The biodiesel yield of 95.2 wt% was obtained when reaction was carried out for 3 h.

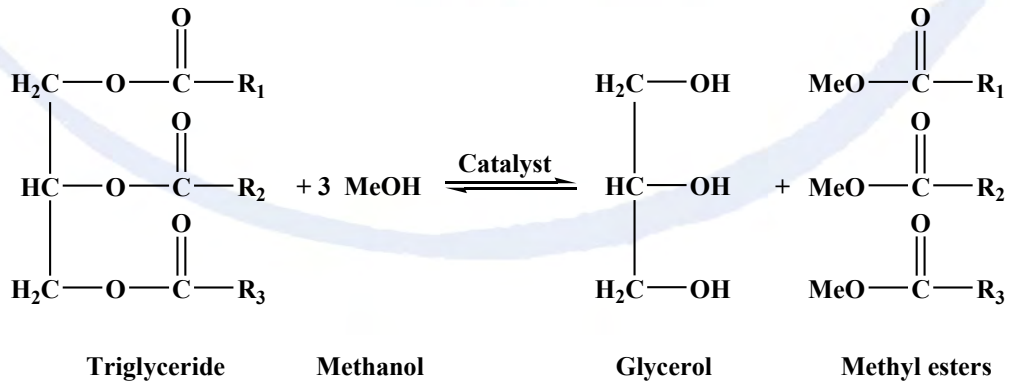
1. INTRODUCTION

The world energy consumption increases because of the growth of population but the petroleum resources are being used up quickly. Therefore, alternative energy sources are needed and biodiesel is one of the answers.

Biodiesel is renewable, non-toxic and biodegradable. Combustion of biodiesel generates lower emission gases, hydrocarbon particles and carcinogens than the conventional diesel derived from petroleum [1]. Biodiesel obtained from renewable biomass feedstocks can be used directly in diesel engines or blended at various proportions with petroleum diesel [2]. Biodiesel consisting of monoalkyl esters can be produced by transesterification of plant oil with methanol or ethanol. The physical and chemical properties of the petroleum diesel and biodiesel such as cetane number are similar. Therefore, several researchers have been interested to produce biodiesel from renewable resources like oil from sunflower, soybean and palm or from waste cooking oil [3-5].

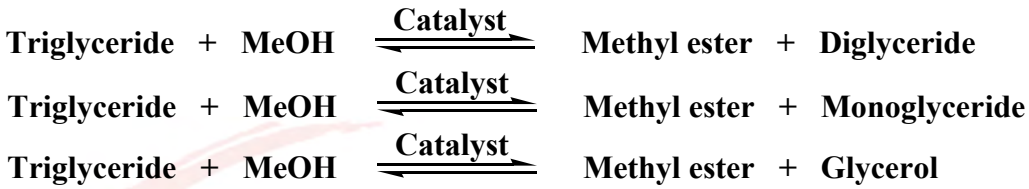
In Thailand, biodiesel has been produced from palm oil or waste cooking oil. However, the supplies of these raw materials, especially, palm oil are sometimes limited depending on the agricultural situation. Once there is a shortage in cooking oil from palm, it is considered not suitable as a biodiesel feedstock. Consequently, alternative raw materials from non-edible plants become more favorable for the biodiesel production. Jatropha seed oil has been used in biodiesel production by many researchers [4, 6]. Jatropha seed oil is one of the interesting biodiesel sources because of several reasons. The Jatropha is a non-food plant because it has toxic in kernel (e.g., curcin). It grows well in Thailand and can be established as an oil source for biodiesel because a large amount of oil can be obtained from the seeds in a short period [4, 7]. The oil content in Jatropha seed is 33.5 wt% [3] and can be extracted using organic solvents such as hexane [6].

Transesterification or alcoholysis is a chemical reaction between triglycerides and alcohol in a presence of a catalyst to produce alkyl esters (biodiesel) and glycerol (see scheme 1). Biodiesel compositions depend on the kind of fats/oils and alcohol. Methanol is the most widely used alcohol because it has low boiling point, low cost and gives higher biodiesel yield than others [4, 8].



Scheme 1. Transesterification for biodiesel production [7].

The transesterification consists of three reversible steps (see scheme 2). First, the triglyceride reacts with methanol to produce diglyceride. Then, the diglyceride reacts with methanol to produce monoglyceride which finally reacts with methanol to produce glycerol [9]. Catalysts for the reaction can be heterogeneous (solid base).



Scheme 2. Transesterification reaction of vegetable oil with methyl ester to ester and glycerol [9].

The use of heterogeneous catalysts is considered because they can be separated easily from the reaction products and can be used with a low quality feedstock (i.e., oil containing FFA and water content) [5]. Several researchers studied transesterification using supported base catalysts. Zeolites are widely used as supports because they have a porous structure and high surface area that can help to disperse active metal. For example, BET surface area of zeolite NaY was 738 m^2/g [10] whereas that of alumina was 208 m^2/g. Noiroj et al. reported that 25 wt% KOH/Al_2O_3 and 10 wt% KOH/NaY gave 91% biodiesel yields for transesterification of palm oil with methanol [11]. However, potassium was leached out from both supports and acted as homogeneous catalyst. The leaching from NaY was less than from alumina. Supamathanon et al. studied transesterification of Jatropha seed oil and methanol at 65 °C for 3 h using K/NaY as a catalyst prepared from potassium acetate buffer (CH_3COOK/CH_3COOH mixture). Such precursor did not cause collapse of the zeolite structure and make it possible for the catalysts to be reused. The catalyst with 12 wt% of K loading gave the biodiesel yield of 73.4%. The result showed a high oil conversion with high biodiesel yield with a short reaction time [7].

Zeolites have negative charge on framework which depends on Si/Al ratio. The charge is neutralized by exchangeable cations such as K^+, Na^+ and Mg^{2+} which reside in the zeolite cavities. When these cations are calcined, they form metal oxides which are strong bases and could catalyze transesterification to produce high biodiesel yield.

The basicity of zeolite can be further improved by loading cations with various methods such as ion-exchange and impregnation. However, the activity of the metal catalyst prepared by impregnation was better than that prepared by ion exchange because high loading could be produced. It was confirmed that the catalyst from impregnation gave more biodiesel yield than that from ion exchange [10]. Ramos et al. studied transesterification of sunflower oil with methanol using Na/NaX prepared by loading zeolite NaX with sodium acetate (CH_3COONa) and got the highest biodiesel yield of 95.1 wt%. The greater activity of zeolite NaX compared to other zeolites could be explained by the presence of a higher concentration of super-basic sites on zeolite NaX (Na_2O in supercage of zeolite X) [10].

Occlusion of metals clusters in the zeolite cavities enhances the basicity by increasing the negative charge of the framework oxygen atoms [12]. Xie et al. reported that the KOH modification in the preparation of KOH/NaX did not destroy the zeolite pore structure that is necessary for catalysis. However, high loading of KOH could cause collapse of the zeolite crystalline structure [13].

Zeolite X has a small crystal size and has a chemical formula $Na_{73}K_{22}Al_{95}Si_{97}O_{384}$• $212H_2O$. Zeolites X and Y have the same faujasite (FAU) structural framework but they are markedly different in composition and properties. Zeolite X has a Si/Al about 1-2 [13] while zeolite Y has Si/Al about 2-4 [14]. Because zeolite X is more basic than zeolite Y, it is expected to be more active and provide a higher biodiesel yield. Thus, the NaX was used in this work.

The goal of this work was to prepare K and Na catalysts on zeolite NaX by impregnation of either acetate buffer or just the acetate solution. The catalysts were characterized and tested for transesterification of Jatropha seed oil.

2. EXPERIMENTTAL

2.1 Preparation of silica from rice husk

Rice husk from a local rice mill was washed with water, dried at 100 °C overnight, refluxed in 3 M HCl for 6 h, filtered and washed repeatedly with water until the filtrate is neutral and dried at 100 °C overnight. The refluxed rice husk was then calcined in a muffle furnace at 550 °C for 6 h resulting in white powder of rice husk silica (RHS). The RHS was dissolved in 4.5 M NaOH solution (4.52 g of RHS in 10 ml of NaOH solution) to produce Na_2SiO_3 solution.

2.2 Synthesis of zeolite NaX

Zeolite NaX was synthesized by the procedure described by Khemthong et al. [15]. The gel with molar ratio 5.5 Na_2O: 1.65 K_2O: 1 Al_2O_3: 2.2 SiO_2: 122 H_2O was prepared from Na_2SiO_3 and $NaAlO_2$. First, solution 1 was prepared by dissolving 1.76 g of $NaAlO_2$ in 2.52 g of DI water and stirring until dissolved. Next, solution 2 was prepared by dissolving 2.45 g of NaOH and 1.76 g of KOH in DI water and stirring until a clear solution is obtained. Then, solution 1 was slowly added into solution 2 and stirred until a clear solution, referred to as solution 3. The dilute Na_2SiO_3 solution was prepared by dissolving 7.24 g of Na_2SiO_3 in 11.34 g of DI water and stirring for 48 h. The mixture was transferred into a polypropylene bottle, closed and sealed with paraffin film. Then, the crystallization was carried out at 70 °C for 3 h and 95 °C for 2 h. The solid sample was filtered, washed with DI water and dried at 110–125 °C overnight. The obtained zeolite NaX was characterized by XRD, XRF and N_2 adsorption-desorption.

2.3 Preparation of catalysts

The K/NaX and Na/NaX were prepared by impregnation adapted from Supamathanon et al. [7] and Ramos et al. [10]. First, the zeolite NaX was dried in an oven at 110 °C for 2 h to remove adsorbed water. Then, 1.6 g of zeolite NaX was impregnated with 2 mL of acetate buffer (B) solution of potassium or sodium (producing K/NaX-B and Na/NaX-B) and just acetate (A) solutions (producing K/NaX-A and Na/NaX-A). The catalysts with various K and Na loadings of 4, 8, 12 and 16 wt% were prepared. The samples were dried at room temperature for 8 h and in an oven at 80 °C overnight before calcination at 400 °C for 3 h. The obtained catalysts were denoted as xK/NaX-B, xNa/NaX-B, xK/NaX-A and xNa/NaX-A, where x = 4, 8, 12 and 16 wt%. All catalysts were characterized by XRD and the best catalysts for the transesterification were

further characterized by TEM and N_2 adsorption-desorption.

2.4 Catalysts characterization

Powder XRD patterns were obtained on a Bruker axs D5005 diffractometer. The Cu Kα X-ray is generated with a current of 40 mA and a potential of 40 kV. The catalysts were scanned from 5 to 50 degrees (2θ) in steps of 0.05 degrees per minute.

The surface area of the catalysts were determined by N_2 adsorption-desorption analysis (Micromeritics, ASAP 2010). Prior to the adsorption measurement, the samples were degassed at 300 °C for 8 h. The relative pressure used for the BET surface area calculation was in the range of 0.01 to 0.2. The pore size and pore volumes were calculated from the adsorption-desorption branches of the isotherm using Barrett-Joyner-Halenda (BJH) method.

Energy dispersive X-ray fluorescence (XRF) spectrometry (Oxford model ED2000) was used to determine the amount of K_2O in the catalysts.

Morphology of micropore were confirmed by TEM Tecnai G^2 20 LaB6 with a 200 kV electron beam. The catalyst powder were dispersed in ethanol, dropped on a copper holey carbon grid and dried at room temperature. Finally, the sample morphology was observed by TEM at a power and magnification that provides clear images.

2.5 Catalytic performance for transesterification

The prepared catalysts were tested for biodiesel production. Firstly, a mixture solution containing 5.0 g of Jatropha seed oil, preheated to 65 °C, 0.2 g of catalyst and 2.9 g of methanol were stirred at 400 rpm with a magnetic stirrer in a 50 mL round-bottom flask equipped with a water-cooled condenser. After the reaction occurs, the mixture was centrifuged at 3000 rpm, the upper layer of the reaction mixture was separated and the excess methanol was removed by a rotary evaporator.

The biodiesel obtained was monitored by TLC. The upper layer of liquid from the reaction mixture was spotted on a TLC plate. The plate was immersed in a solvent mixture of petroleum ether/diethyl ether/glacial acetic acid (85:15:1, v/v/v) [7] and exposed to iodine vapor to estimate the conversion.

The compositions of biodiesel from the reaction were determined by a gas chromatograph (Hewlette Packard, GC-HP6890-Series) using internal standard method equipped with a flame ionization detector (FID) and 30-meter HP-INNOWAX polyethylene glycol capillary column with 0.32 mm id and 0.15 μm film thickness. The initial column temperature was held at 140 °C for 3 min before ramping to 240 °C with a rate of 10 °C/min and held for 8 min at the final temperature. The following equation [7] was used for the yield calculation:

$$\textbf{yield} = \frac{(C_{ester} \times n)}{p_{oil}} \times 100\%$$

Equation 1. The yield of oil to biodiesel was calculated from the content of methyl esters analyzed by GC [7].

where C_{ester} (g/mL) is the mass concentration of methyl ester which was acquired by GC, n is the diluted multiple of methyl esters, which can be calculated using the total volume of then-hexane and internal standard solution divided by the volume of methyl ester sample and roil (g/mL) is the density of Jatropha seed oil [7].

3. RESULTS AND DISCUSSION

3.1 Catalysts characterization by XRD

The XRD patterns of zeolite NaX and K/NaX-B with various K loading are shown in Fig. 1. Characteristic peaks of NaX similar to those in the literature [15] were still observed in all catalysts indicating that impregnation with the buffer solution did not destroy the zeolite structure. The peaks intensity of the zeolite NaX decreased after increase K loading due to decrease in zeolite crystallinity potassium species and secondary scattering of X-ray. Xie et al. [13] also stated that KOH/NaX samples with KOH loading of 4–14 wt% gave similar XRD pattern to the parent NaX. Moreover, the new phase of K species such as K_2O phase (2θ =31° and 39°) were not observed, indicating good dispersion of K on zeolite NaX [10].

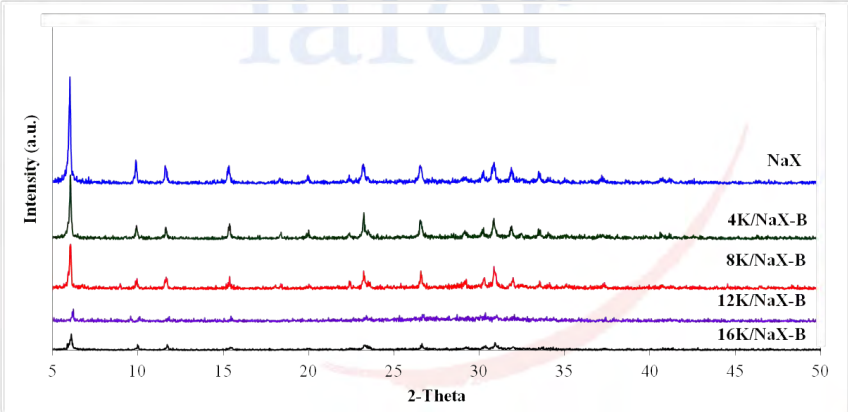


Fig. 1. XRD patterns of the zeolite NaX and xK/NaX-B catalysts with loading 4, 8, 12 and 16 wt%.

The XRD patterns of zeolite NaX and K/NaX-A at various loading are shown in Fig. 2. When the amount of loading increased the peak intensity of zeolite NaX decreased too. The XRD patterns were almost the same as the typical pattern of zeolite NaX because K can be well dispersed on the zeolite NaX.

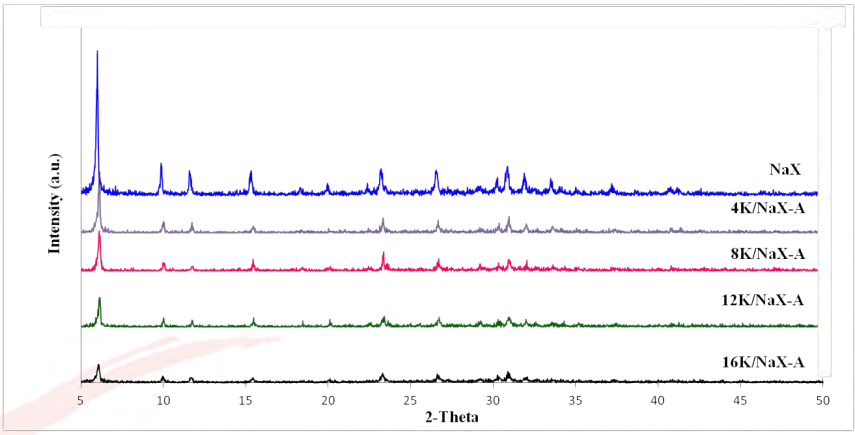


Fig. 2. XRD patterns of the zeolite NaX and xK/NaX-A catalysts with loading 4, 8, 12 and 16 wt%.

The XRD patterns of zeolite NaX, Na/NaX-B and Na/NaX-A at various Na loadings are shown in Fig. 3 and 4, respectively. All catalysts had similar XRD patterns to that of the parent NaX but the intensities decreased with increase Na loading. However, a peak at 9° corresponding to CH_3COONa was observed on the samples with 12 and 16% loading. The catalysts were calcined at 400 °C and this temperature was not high enough to decompose Na acetate completely. These catalysts could behave as both homogenous and heterogeneous catalysts. When these catalysts were tested for transesterification, high biodiesel yield was obtained. They gave high biodiesel yield but I will not study.

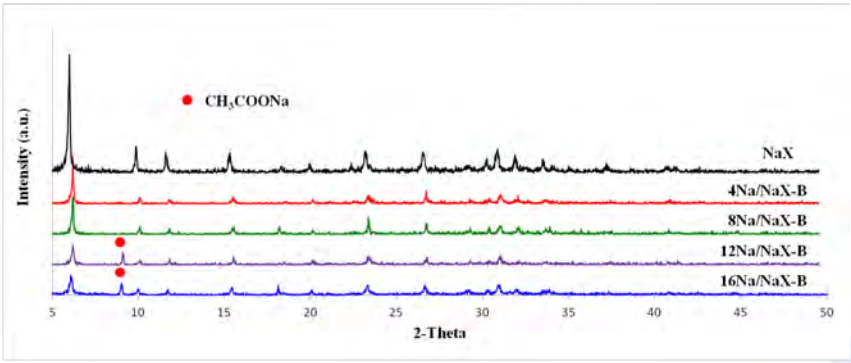


Fig. 3. XRD patterns of the zeolite NaX and xNa/NaX-B catalysts with loading 4, 8, 12 and 16 wt%.

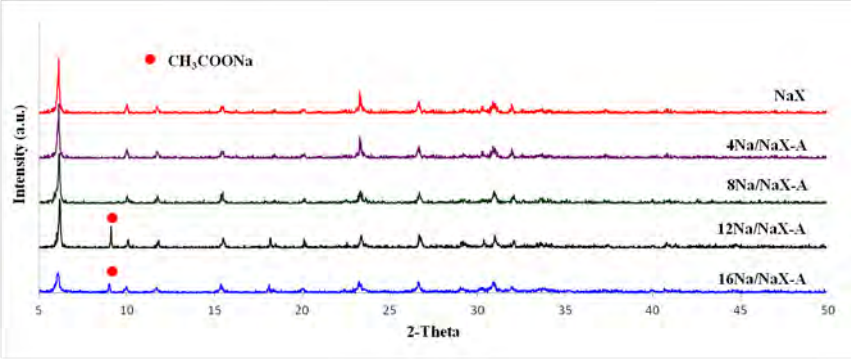


Fig. 4. XRD patterns of the zeolite NaX and xNa/NaX-A catalysts with loading 4, 8, 12 and 16 wt%.

3.2 Transesterification

3.2.1 Effect of K loading in K/NaX-B

The effect of potassium loading in xK/NaX-B on the conversion of Jatropha seed oil was followed by TLC. The results after transesterification for 3 h on these catalysts are shown in Fig. 5. According to the spot size of crude oil and ester, the conversion increased with K loading and the 16 wt% K gave the complete conversion because only a spot of methyl esters was observed. The 16K/NaX-B catalyst was used for further study.

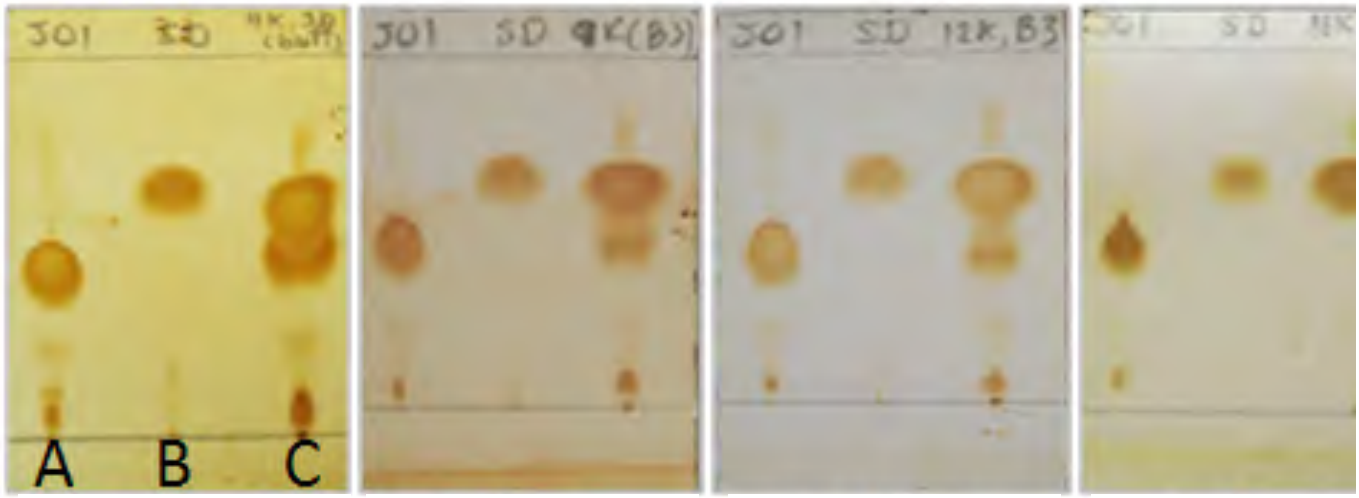


Fig. 5. TLC plate of product from transesterification with 4, 8, 12 and 16 wt% K/NaX-B; (a) Crude Jatropha seed oil, (b) standard methyl ester, (c) product. Reaction condition: methanol to oil molar ratio = 16:1, and temperature = 65 °C.

3.2.2 Effect of K loading in K/NaX-A

The effect of potassium concentration on xK/NaX-A on transesterification was also studied. The results are shown in Fig. 6. The biodiesel yield increased with K loading but spot of crude oil was observed indicating incomplete conversion. Thus, K catalysts prepared from acetate buffer were better than those prepare from acetate. It is believed that the agglomeration of the active K phase or the covering of the basic sites by the excess K occurred, and hence a lowering of the surface area of the catalyst and less activity [11]. The K from buffer solution can be dispersed on zeolite NaX better than the K from acetate solution.

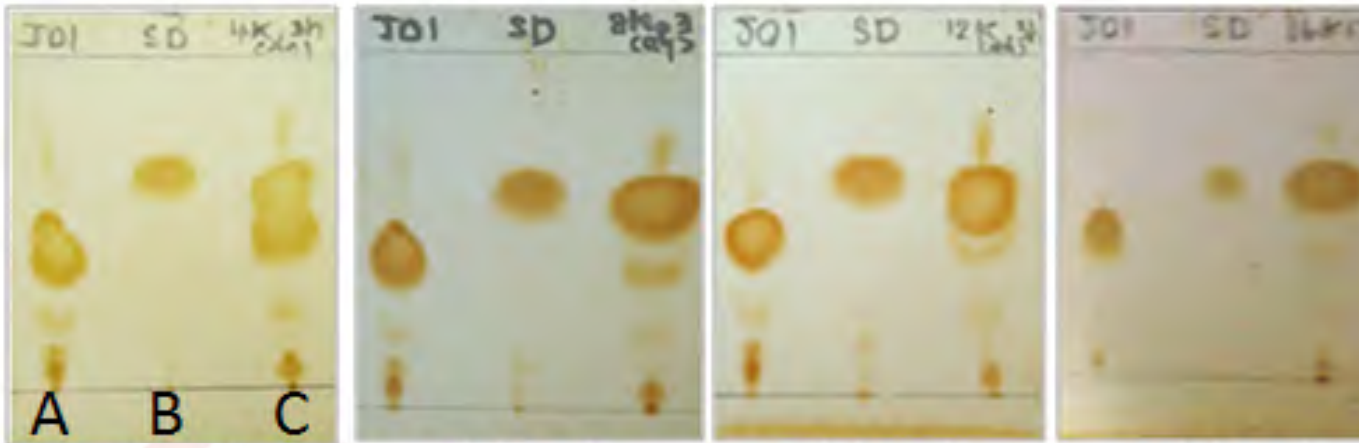


Fig. 6. TLC plate of product from transesterification with 4, 8, 12 and 16 wt% K/NaX-A; (a) Crude Jatropha seed oil, (b) standard methyl ester, (c) product. Reaction condition: methanol to oil molar ratio = 16:1, and temperature = 65 °C.

3.2.3 Effect of K loading in K/NaX-B and K/NaX- A on the biodiesel yield

The biodiesel yields from K/NaX-B and K/NaX-A determined by GC are shown in Fig.7. These results agreed with the estimation by TLC that the best catalyst was 16K/NaX-B. The biodiesel from 16K/NaX-B was 95.2%. Only this catalyst was further tested at different reaction time.

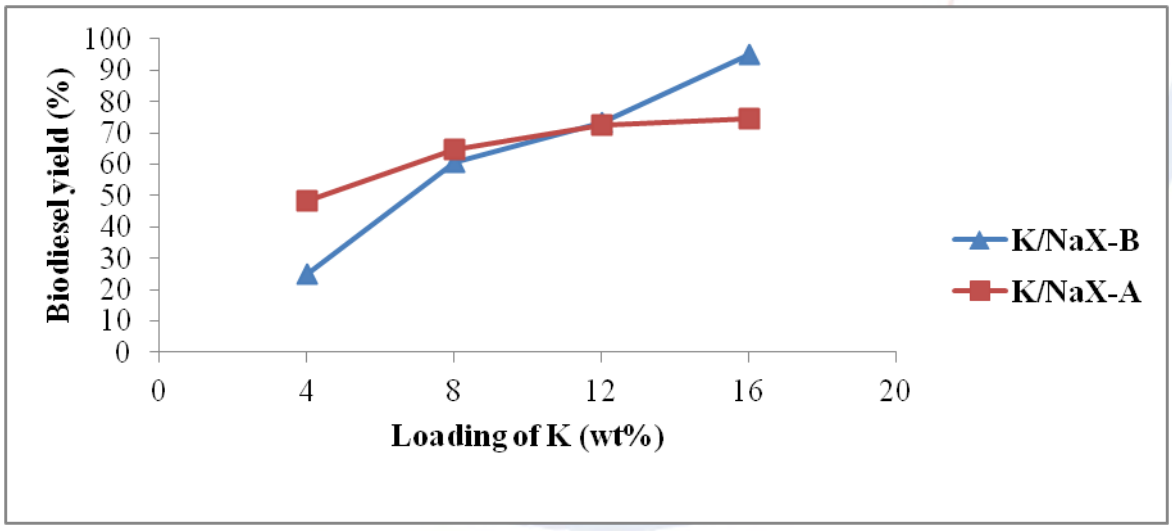


Fig. 7. Effect of wt% loading of K from buffer and acetate solution on the biodiesel yield

3.2.4 Effect of reaction time of 16K/NaX-B on the biodiesel yield

The effect of reaction time on biodiesel yield was studied on 16K/NaX-B with 1, 2 and 3 hours. From TLC results (not shown) the conversion increased with time and only 16K/NaX-B gave a complete conversion. Figure 8 shows the yields obtained from GC analysis of the products at various reaction times. The optimum time for transesterification of Jatropha seed oil with methanol was 3 h and the yield was 95.2 wt%.

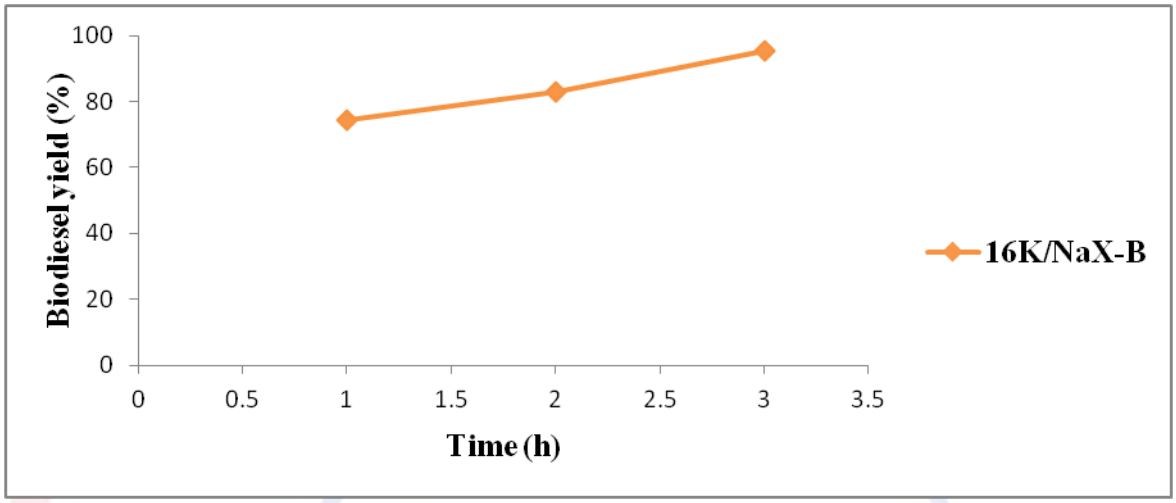


Fig. 8. The reaction time of 16K/NaX-B on the biodiesel yield

3.3 Characterization of xK/NaX-B and xK/NaX-A by XRF

The XRF of zeolite NaX and catalysts presented in Table 1. The results show that the K_2O from the catalysts increased with increasing K loading. The K from buffer solution gave the K_2O higher than acetate solution. The K_2O species presented of a higher concentration of basic sites on the catalysts.

Table 1 The XRF analysis results of zeolite NaX, xK/NaX-B and xK/NaX-A catalysts

Sample	K_2O (wt %)
Zeolite NaX (Si/Al = 1.35)	-
4K/NaX-B	23.9
8K/NaX-B	30.4
12K/NaX-B	30.6
16K/NaX-B	38.0
4K/NaX-A	23.3
8K/NaX-A	23.5
12K/NaX-A	26.4
16K/NaX-A	31.1

3.4 Characterization of 16K/NaX-B and 16K/NaX-A by N_2 adsorption-desorption

The BET surface area and pore volume of zeolite NaX and catalysts are shown in Table 2. The results show that the surface area and micropore volume of zeolite NaX decrease after metal loading because of the K dispersed on surface and occluded in the zeolite pores. The 16K/NaX-B catalyst had a lower surface area and micropore volume than the 16K/NaX-A catalyst due to K buffer can be dispersed on surface and occluded in the zeolite pores more than 16K/NaX-A. The external surface area of 16K/NaX-A had a lowest because of the K dispersed on the external surface more than occluded in the zeolite pore.

Table 2 Surface area of zeolite NaX, 16K/NaX-B and 16K/NaX-A catalysts.

Sample	BET surface area ($m^2 . g^{-1}$)	Micropore volume ($cm^3 g^{-1}$)	Micropore area ($m^2 . g^{-1}$)	External surface area ($m^2 . g^{-1}$)
Zeolite NaX	650	0.27	578	72
16K/NaX-B	250	0.09	193	57
16K/NaX-A	337	0.14	299	38

3.5 Characterization of zeolite NaX, 12, 16K/NaX-B and 16K/NaX-A by TEM

The morphology of zeolite NaX, 12K/NaX-B, 16K/NaX-B, and 16K/NaX-A presented in Fig. 9a, b, c, and d, respectively. The morphology of all catalysts is polycrystalline zeolite.

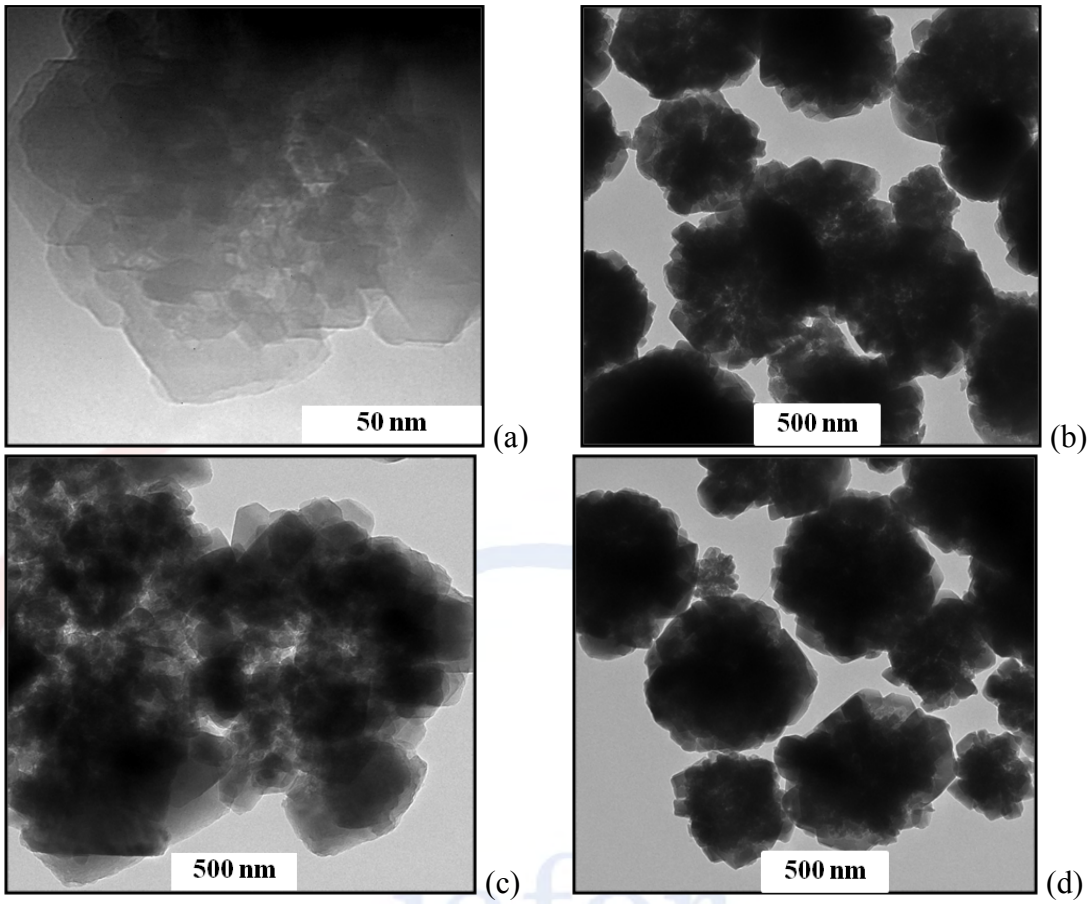


Fig. 9. TEM image of of the zeolite NaX (a), 12K/NaX-B (b), 16K/NaX-B (c) and 16Na/NaX-A (d)

4. CONCLUSION

Transesterification of Jatropha seed oil with methanol was carried out using K and Na loaded on zeolite NaX by impregnation method. With either acetate buffer or acetate solutions, the zeolite structure was not destroyed. However, calcinations at 400 °C were too low to decompose sodium acetate completely. Although high biodiesel yields were obtained from 16Na/NaX-B and 16Na/NaX-A, they were not further studied because the performance was from both homogeneous and heterogeneous catalysts. For xK/NaX-B and xK/NaX-A the conversion increased with K loading but only 16K/NaX-B gave a complete conversion with the yield of 95.2 %. The optimum reaction time over 3 h.

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Catalyst Derived from the Natural Waste of Biodiesel Production

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0455

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Abstract:

The alternative catalyst from the natural waste product of biodiesel production was studied. The selected catalysts were wood ash derived from the charcoal remains of Longan *Dimocarpus longan*, Jackfruit *Artocarpus heterophyllus*, Tamarind *Tamarindus indica* and Taengwood *Shorea obtusa*. All the catalysts were considered basic and the SEM-EDS revealed that the catalysts were composed of carbon, oxygen, potassium and calcium. It was found that under the optimum conditions (catalyst concentration of 10 % (w/w), methanol/oil molar ratio of 100:1, a temperature at 60°C and a retention time of 60 minutes), the ash from Longan gave the best yield, at 92% for the methyl ester and 89% for ethyl ester.

1. Introduction

Biodiesel is an alternative fuel to fossil diesel. It can be produced from vegetable oil, animal oil/fats and waste cooking oil *via* transesterification [1]. Biodiesel has several distinct advantages over diesel including being renewable, energy efficient, safe, biodegradable and environmentally friendly. Also, a higher flash point makes it safer for transportation and storage [2][3]. There are four routes in transesterification to biodiesel: base-catalyzed, acid-catalyzed, enzyme catalyzed, and non-catalytic methods [3]. Methanol is the most used alcohol for producing biodiesel, although other alcohols such as ethanol and isopropanol could be used in the process as well [1].

Most of the general biodiesel production is processed using homogeneous alkaline catalysts (basic and acid), the advantages include high activity and mild reaction conditions. However, the catalysts cannot be reused, which demonstrates the major disadvantage of homogeneous catalysts. In addition, the difficulty in eliminating the catalyst increases the cost and releases wastewater after the reaction. On the other hand, heterogeneous catalysts could reduce the additional cost of separation and purification. The heterogeneous catalysts have been reported to be mixed of zinc and aluminum oxides, as well as zeolites and others [4][5]. Moreover, waste egg shell supported with fly ash was used for transesterification [6].

In many developing countries, firewood is one of the important sources for household energy. Firewood accounts for 14% of world energy consumption but in developing countries firewood is used for energy at up to 36% [7]. The National Statistical Office of Thailand explored the household expense of energy in the year 2011 and reported that the expense of energy was 10% of the total expense. Charcoal and firewood, which were 2.1% of the total expense, suggested that Thai people are regularly using firewood in their daily life and produce a large amount of ash [8].

Although various types of trees are used as firewood in Thailand, four trees are selected in our work *i.e*. Longan (*Dimocarpus longan*), Jackfruit (*Artocarpus heterophyllus*), Tamarind (*Tamarindus indica*) and Taengwood (*Shorea obtuse*). These trees are local trees in the North of Thailand and are commonly used as firewood. Ashes from these trees were explored for their efficiencies in biodiesel production. Properties of the obtained biodiesel were also studied. Finally, the optimal condition for the production of biodiesel employing the selected ash were reported.

2. Experimental Section

2.1 Materials

Palm oil was purchased from the local market. Methanol was distilled at its boiling point for use except for ethanol which was used as an analytical grade reagent. The wood ashes were obtained from the branches of Longan, Jackfruit, Tamarind and Taengwood which were collected in Chiang Mai, Thailand in 2011.

2.2 Catalysts Preparation

Wood ash was kept from burning wood chips, then wood ashes were filtered through a stainless steel sieve mesh 32. The wood ashes were heated in an oven at 100ºC for 60 minutes and kept in a polyethylene bottle at room temperature.

2.3 Transesterification reaction

The palm oil (10 g.), methanol (variable) and catalyst (variable) from wood ash were mixed in a 100 mL round bottom flask with condenser. Each mixture was refluxed for the required time. Once the reaction was completed, the catalyst was filtered. The reaction mixture was washed with water (3 x 50 ml) to remove glycerol, then the methyl ester was separated and dried with anhydrous sodium sulfate. For ethyl ester, ethanol was used in the reaction by the optimization condition of methyl ester production.

The percentage yield used the final product yield as relative to the weight of oil at the start and was calculated by formula (1) [9].

$$Yield\ (\%) = \left(\frac{weight\ of\ biodiesel}{weight\ of\ raw\ oil/fat}\right) X\ 100 \qquad (1)$$

2.4 Analysis

The biodiesel was column chromatographed and characterized by gas chromatography- mass spectrometry (GC-MS) on an Agilent 6890 series with a capillary split injector. The chromatographic separation was achieved on a 30 m x 250 µm x 0.25 µm HP-5MS column. The surface morphology of the wood ash catalysts were determined using Scanning electron microscopic (SEM) at 15.0 kV (JEOL JSM-6335F) and were analyzed for elements by Energy Dispersive Spectrometry (EDS). The ^{1}H-NMR data were record on Bruker DRX 400 MHz using $CDCl_3$ as a solvent. Fourier transformed infrared FT-IR were recorded on Bruker Tensor27 FT-IR Spectrometer with NaCl cells and operated in the range of 400 – 4,000 cm^{-1}.

Biodiesel was analyzed by the Petroleum Authority of Thailand (PTT). The testing methods for product properties required for biodiesel standards were evaluated according to the ASTM and EN standard methods as follows: density at 15ºC and 30ºC (ASTM D4052-09), viscosity at 40ºC (ASTM D445-09), flash point (ASTM D93-10, procedure A), total acid number (ASTM D664-09), copper strip corrosion (ASTM D130-04E1) and free glycerin and total glycerin (EN 14105: 2003).

3. Results and discussion

3.1 Effect of transesterification process variable

3.1.1 Influence of catalyst type

With regard to the effects of the catalyst type on the yield of biodiesel, it was noted that the different wood ashes had various levels of efficiency. The reactions included 10 g. of palm oil and methanol 15 ml (methanol/oil molar ratio 38:1) at 60°C for 60 min. The wood ash catalysts from Longan and Jackfruit displayed a high yield of 79% and 77%, respectively. The catalyst from Tamarind provided a % yield less than Longan and Jackfruit. In addition, the biodiesel production from Taengwood ash generated the lowest yield (Fig. 1). As a result, the catalyst from Longan was the best catalyst for biodiesel production. Also, there is an economic plant in Chiang Mai Thailand, therefore, Longan was selected for further experimentation.

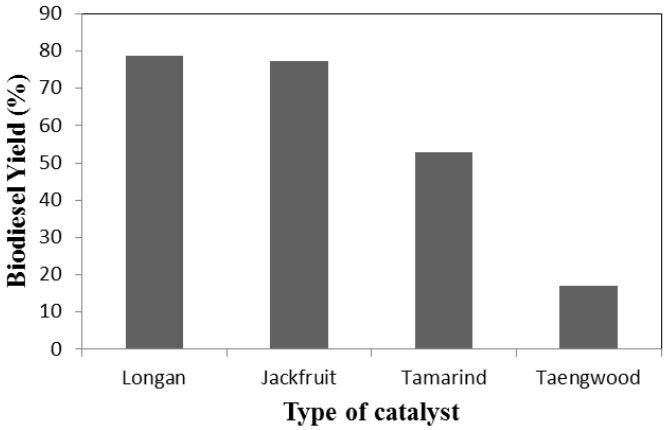

Fig. 1 Effect of catalyst on the yield of biodiesel.

3.1.2 Effect of catalyst content

Wood ash from Longan in the range of 0.1-5.0 g. was used as the catalyst to investigate the effect of catalyst content on transesterification of palm oil. The biodiesel yield increased to a maximum in a 1.0 g. of catalyst, but then decreased with greater catalyst content (Fig. 2a). A higher amount of the catalyst from Longan decreased the ability of biodiesel production because higher amounts of ash could disperse less in a suspension mixture that was absorbed into the ash. The catalyst content that was chosen for optimization of transesterification was 1.0 g. for 10 g. of palm oil and methanol 15 ml (methanol/oil molar ratio 38:1) at 60°C for 60 min.

3.1.3 Effect of methanol/oil molar ratio

The transesterification was performed with methanol 10, 15, 20, 30 and 40 ml (methanol/oil molar ratio of 25:1, 38:1, 50:1, 75:1 and 100:1, respectively) (Fig. 2b) and indicated that the biodiesel yield of palm oil to fatty acid ester increased with the increasing molar ratios and increased to a maximum at methanol/oil molar ratio of 100. Considering the biodiesel yield and energy economy, it is best to choose 100 as the methanol/oil molar ratio for the transesterification of palm oil at 10 g. of palm oil at 60°C for 60 min.

3.1.4 Effect of temperature

The effect of temperature on transesterification was studied at different temperatures (25, 40, 60 and 80ºC, respectively) with 10 g. of palm oil and 40 ml of methanol (methanol/oil molar ratio 100:1) for 60 min (Fig. 2c). The biodiesel yield increased when the temperature increased. A temperature at 60°C produced the highest yield of biodiesel with a constant yield at temperatures greater than 60°C.

3.1.5 Effect of reaction time

The reaction time was varied in a range of 15-90 min with 10 g. of palm oil and 40 ml of methanol (methanol/oil molar ratio 100:1) at 60ºC (Fig. 2d). The biodiesel yield increased as the time increased up to 60 min at which point the yield stabilized at 93 % and the % yield was almost constant as the time was increased.

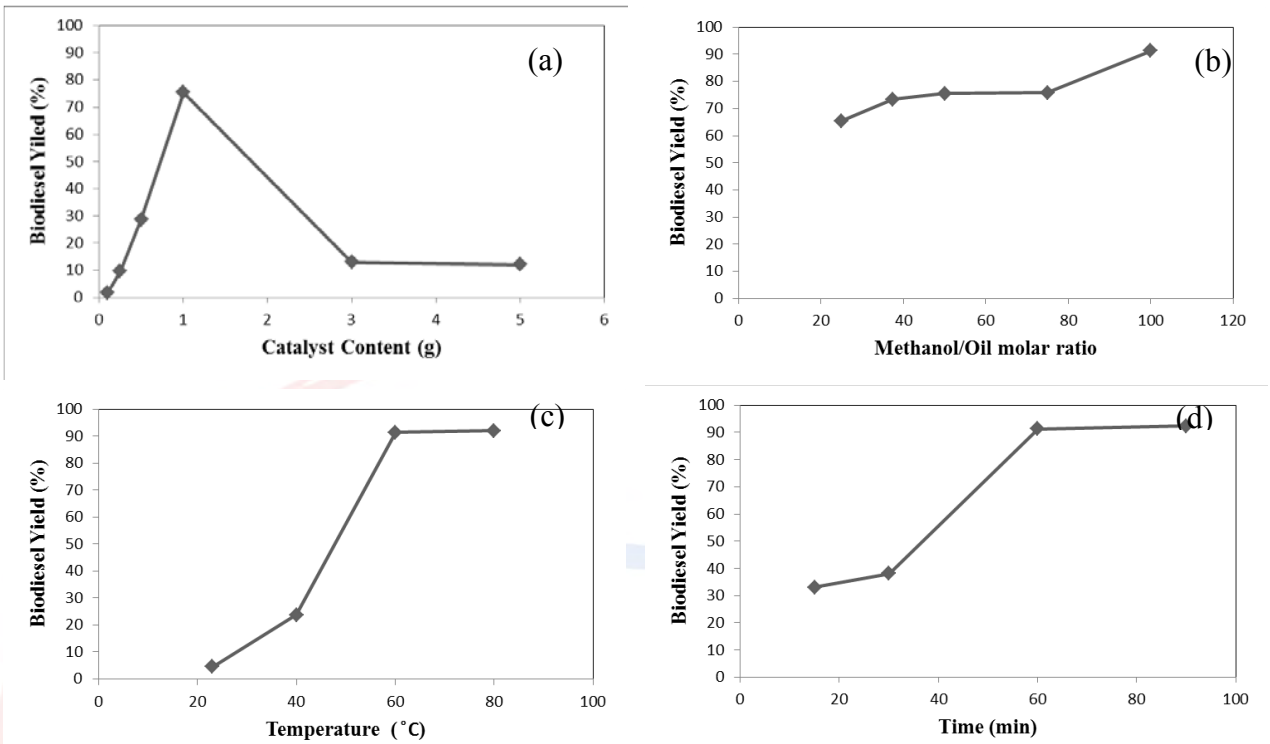

Fig. 2 Effect of process variable on transesterification of palm oil; (a) Catalyst content (b) Methanol/oil molar ratio (c) Temperature (d) Reaction time

3.2 Analysis of the catalyst

The morphology, size and microstructure of the selected catalysts from the Longan, Jackfruit, Tamarind and Taengwood were investigated in detail through the SEM images.

Energy dispersive X-ray spectroscopy (EDS) was used to characterize the composition of these composite materials. All catalysts were composed of carbon, oxygen, potassium and calcium as the major elements.

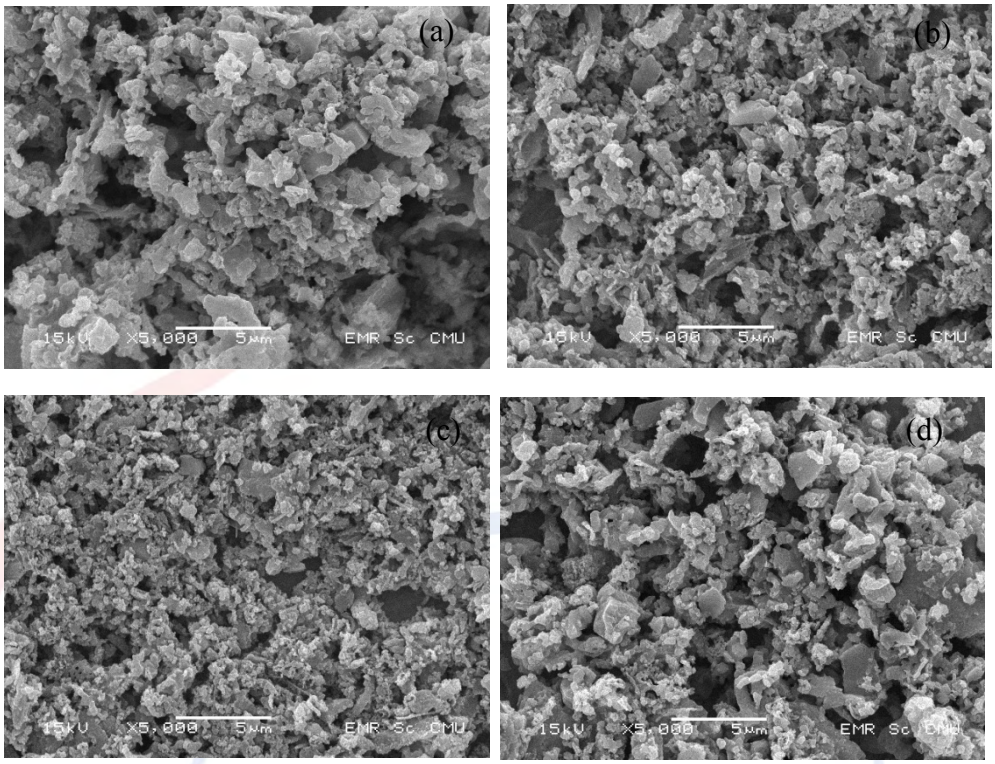

Fig. 3 SEM image catalysts were wood ash derived from the charcoal remains of (a) Longan, (b) Jackfruit, (c) Tamarind and (d) Taengwood

3.3 Biodiesel Composition

Biodiesels from methanol and ethanol were analyzed for their compositions by GC-MS. The esters are derived for fatty acids; oleic, palmitic, linoleic, stearic, myristic and lauric acid (Table 1).

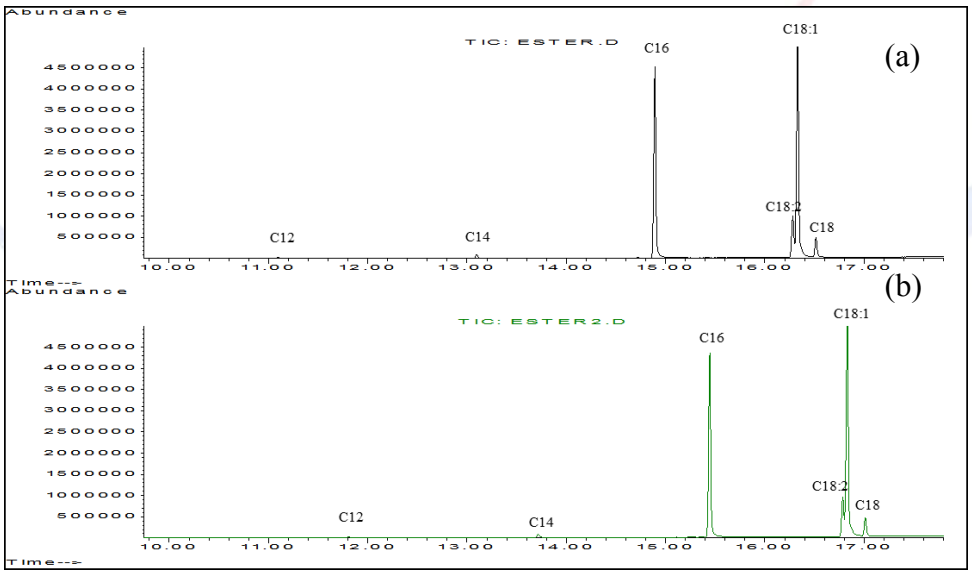

Fig. 4 GC-MS Chromatogram of methyl and ethyl ester obtained from Longan ash catalyst

(a) methyl ester (b) ethyl ester

Table 1
Fatty acid composition of palm oil methyl and ethyl ester

Structure	Fatty acid (%)	Methyl ester	Ethyl ester
C12	Lauric acid	0.345	0.300
C14	Myristic acid	0.846	0.795
C16	Palmitic acid	38.858	38.687
C18	Stearic acid	4.401	4.328
C18:1	Oleic acid	46.702	47.505
C18:2	Linoleic acid	8.849	8.385

3.4 Characterization of fatty acid ester by ^{1}H-NMR and FT-IR analysis

Methyl ester displayed the methyl ester proton at d 3.66 in the ^{1}H-NMR spectrum (Fig. 5a) while the ethyl esters showed the ethyl ester unit at d 4.11 and 2.27 (Fig. 5b). The IR spectrum exhibited the C=O and C-O of ester functional group at 1744 and 1171 cm^{-1} for methyl ester and 1739 and 1179 cm^{-1} for ethyl ester (Fig. 6).

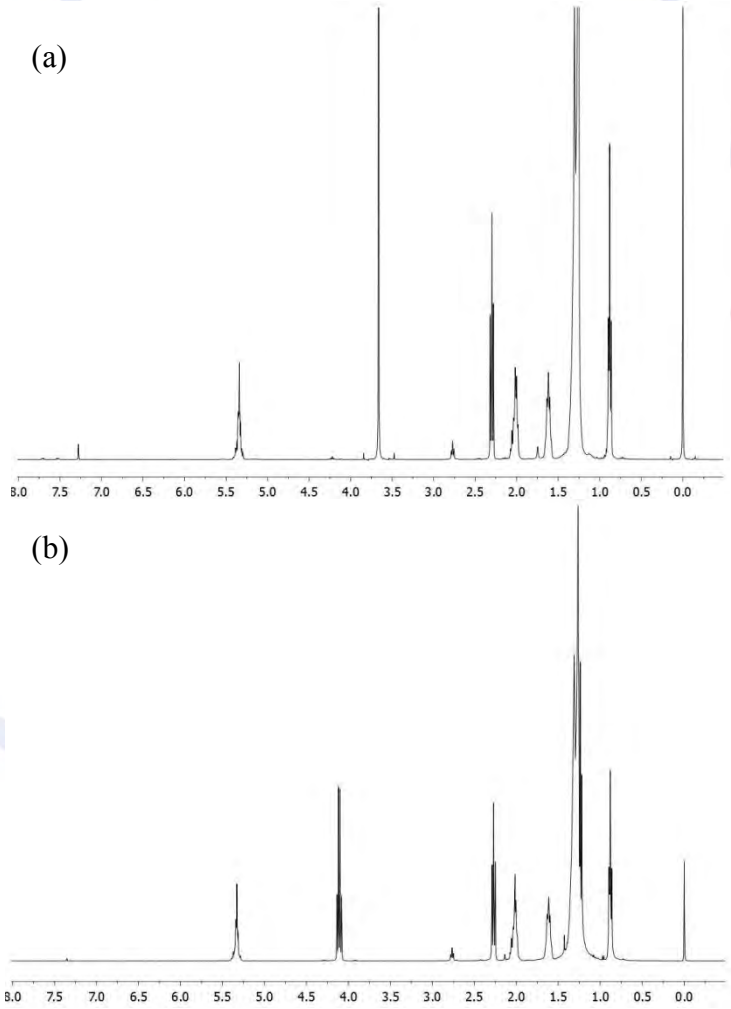

Fig. 5 ^{1}H-NMR spectra of (a) methyl ester (b) ethyl ester

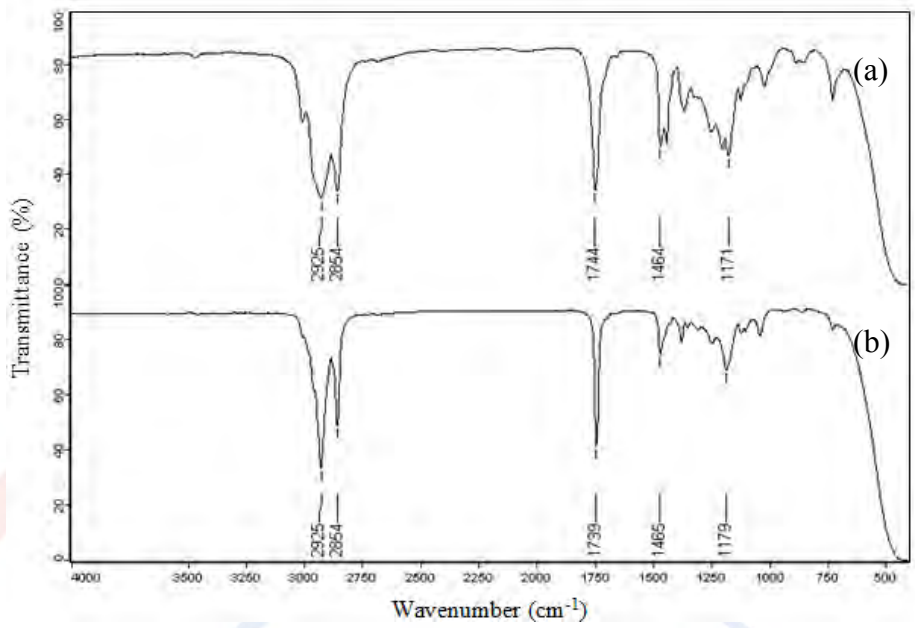

Fig. 6 FT-IR spectra of (a) methyl ester (b) ethyl ester

3.5 Physical properties of methyl and ethyl esters

The properties included density, viscosity, flash point, total acid number, copper strip corrosion, free glycerin and total glycerin of the methyl and ethyl ester from transesterification of palm oil with methanol and ethanol and were analyzed according to ASTM and EN standards with the results given below.

Table 2
Physical properties of methyl ester and ethyl ester from fatty acid.

Test Item	Unit	Test Method	Limit	Biodiesel of	
				Methyl ester	Ethyl ester
Density at 30ºC	kg/m^3	ASTM D 4052-09	Report	865.4	860.3
Density at 15ºC	kg/m^3	ASTM D 4052-09	860 - 900	875.9	870.8
viscosity at 40ºC	mm^2/s	ASTM D 445-09	3.5 - 5.0	4.117	4.694
Flash point (P.M.)	ºC	ASTM D 93-10	Min. 120	120	111.1
Total Acid Number	mg KOH/g	ASTM D 664-09	Max. 0.5	0.04	0.04
Copper Strip Corrosion (3h/50ºC),	No.	ASTM D 130-04E1	Max.No.1	1a	1a
Free glycerin,	% wt	EN 14105 : 2003	Max. 0.02	0.00	0.00
Total glycerin	% wt	EN 14105 : 2003	Max. 0.25	0.10	0.23

From the results, it was revealed that the methyl ester properties are in the range of ASTM and EN standard, while the ethyl ester flash point is lower than the limitation. However, most of the results are within the standard range.

4. Conclusion

The optimum biodiesel yield was obtained using the catalyst from Longan ash 1.0 g., methanol/oil molar ratio100:1 at 60°C and 60 min. Longan ash gave the best yield at 92% and 89% for methyl and ethyl esters, respectively.

The SEM-EDS analysis of ash revealed that the catalysts were composed of carbon, oxygen, potassium and calcium as the major elements.

GC-MS chromatogram showed the structures of methyl and ethyl esters. ^{1}H-NMR and FT-IR analysis showed the detail of the corresponding esters.

Wood ash from Longan was an alternative catalyst for biodiesel production. Under these conditions, the biodiesel was obtained in high yields and the properties are in accordance with the ASTM and EN standard. This wood ash could be obtained from every household in order to produce biodiesel with minimal cost. It is considered environmentally friendly and safe to be used.

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The Impacts of Climatic Extremes on Coastal and Marine Biodiversity in Singapore and Management Challenges

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Abstract:

Climate change impacts are expected to impose further challenges to the management of the coastal and marine environment. The island nation of Singapore has lost 96% of its mangroves and 60% of its coral reefs to coastal development and maintaining the remaining existing habitats is crucial. Two recent extreme climatic events in Singapore provide important observations to coastal habitat managers in anticipation of a warmer climate with more intense precipitation and extreme weather events in the future. Mass mortality of intertidal organisms occurred in the northeastern part of Singapore caused by an unusually high intensity rainfall over Singapore and Southern Peninsular Malaysia. The extended period of high rainfall from December 2006 to January 2007 and subsequent discharge of large volumes of freshwater from the nearby Johore River resulted in a sustained salinity reduction. In 1998 and 2010, ENSO driven elevated sea temperatures triggered mass coral bleaching events, resulting in 25% (1998) and 10% (2010) coral mortality. The lack of long-term monitoring data on local biodiversity and environmental parameters impedes deeper understanding of the effects of these climatic events on the ecosystems and may not allow for more effective long-term management strategies that are more resilient to extreme weather occurrences.

Introduction

Located in tropical Southeast Asia, which is the global hotspot for coral reefs, the island nation of Singapore has lost 96% of its mangroves (Ng and Sivasothi, 1999) and 60% of its coral reefs (Burke et al., 2002) to coastal development over the past five decades. With limited land area of around 700km^2 supporting a growing population of more than 5 million, maintaining its remaining coastal and marine habitats is crucial. However, this is extremely challenging due to the pressure from development, and the increasingly inevitable climate change impacts.

Similar to coastal and marine environments worldwide, those in Singapore are also exposed to climate change impacts such as elevated sea surface temperatures, increased frequencies of extreme weather, ocean acidification and sea level rise (Chou, 1994). According to the fourth assessment report of the Intergovernmental Panel on Climate Change (Meehl et al., 2007), global sea surface temperature (SST) and sea level are predicted to increase by 1.5 – 2.6°C and 0.19 – 0.58m respectively by the end of this century, while ocean pH is projected to drop by 0.1 – 0.4 units from the current pH of 8.1. More recent studies have since suggested that these predictions of sea level rise have been underestimated, and the increment could be as high as 2m (e.g. Grinsted et al., 2009; Horton et al., 2008; Rahmstorf, 2007, 2010; Vermeer and Rahmstorf, 2009).

These climate impacts generate accompanying environmental effects on coastal and marine systems through coastal erosion, sudden salinity fluctuation, increased sedimentation, nutrient loading, salt water intrusion, coastal inundation, and changes in coastal geomorphology and circulation patterns (Chou, 1992). Mangrove ecosystems are threatened by coastal inundation and erosion owing to sea level rise, while organisms in the intertidal area are vulnerable to osmotic stresses caused by sudden fluctuations in salinity, which are in turn triggered by extreme rainfall events. Coral reefs on the other hand, are susceptible to thermal stress, increased sedimentation and nutrient loading.

With the impending threats brought about by both the ongoing and future climatic changes, there is an urgent need to implement mitigation measures that can ensure the continuation of the local flora and fauna. This is especially imperative since anthropogenic stresses have weakened the state of the natural environment, and are likely to also exacerbate further climatic impacts. Climate change impact assessments on coastal habitats in Singapore is therefore of utmost importance in aiding habitat managers and policy makers. However, limited records of past and present environmental and biodiversity data, together with difficulties in segregating the impacts of climate change from anthropogenic impacts make such assessments difficult. Two recent extreme climatic events in Singapore provide important lessons to coastal habitat managers in anticipation of a warmer climate with more extreme weather events in the future.

Extreme rainfall and mass mortalities of intertidal organisms at Chek Jawa

Chek Jawa is an intertidal flat located on Pulau Ubin (Ubin Island), an offshore island northeast of mainland Singapore. It is a precious part of the natural heritage of Singapore due to the six different habitats found there, i.e. coastal forest, rocky shore, sandy beach, mangrove forest, seagrass bed, and the coral rubble flat (Tan and Yeo, 2003). Exposed during low tides, the intertidal area and seagrass beds support numerous locally rare fauna, including various species of carpet anemones, sea stars, sand dollars and sea cucumbers.

Surrounded by the eastern Johor Straits, Chek Jawa is located directly south, and downstream of the Johor River. Due to freshwater discharge from Johor, the southern peninsular state of Malaysia, Chek Jawa is sometimes subjected to salinity depression akin to estuarine environments . Salinity of the Eastern Johor Strait ranges between 21.5 and 33.0 parts per thousand, with sites further away from the causeway recording higher salinity. Such a pattern is highly influenced by monsoon, rainfall and freshwater discharge from Singapore and Southern Johor (Lim, 1984, Hajisamae and Chou, 2003).

In 2007, mass mortalities of intertidal organisms were first observed on 1st of January by conservation volunteers. Based on anecdotal records of regular visitors to Chek Jawa, macrofauna such as the carpet anemone (*Stichodactyla haddoni*), sea cucumbers (*Holothuria scabra* and *Phyllophorus* sp.), the noble volute (*Cymbiola nobilis*), sea stars (*Archaster typicus* and *Protoreaster nodosus*) and sponges (Phylum Porifera) were affected (unpubl. data).

This devastating episode is believed to have been caused by a large drop in salinity brought about by the unusually intense and prolonged periods of rainfall in both Singapore and Southern Peninsular Malaysia. There were three periods of high rainfall in less than 30 days between December 2006 and January 2007, which have been attributed to interactions between the strong northeasterly monsoonal winds that penetrated further south than usual. They hit the southern end of the Malaysian Peninsula instead of the usual middle section, and the regional circulation phenomenon Madden-Julian Oscillation (MJO) (Tangang et al., 2008). The excessive rainfall and close proximity of Chek Jawa to the Johor River might have led to a sustained period of low water salinity throughout December and January, causing chronic damage to the intertidal community and impairing its recovery.

Recovery occurred as weather conditions returned to normal, with the re-establishment of populations that were decimated due to the extreme rainfall. However, as of 2011, full recovery of the intertidal community was perceived by conservation volunteers who frequented the site, to be incomplete. Apart from causing mass mortalities, the impact allowed the establishment of other species not previously known from the site. The Asian mussel *Musculista senhousia*, which originated from northern Southeast Asia for example, has previously spread to Singapore as an introduced species. Not previously recorded at Chek Jawa, large populations of this mussel quickly established within a few months following the mass death event (Loh, 2008). This opportunistic colonization of Chek Jawa by *M. senhousia* demonstrated the potential of an invasive species to dominate a biodiversity-rich natural habitat, following an abrupt environmental change.

Elevated sea surface temperatures and mass coral bleaching events in 1998 and 2010.

Intense coastal development has largely confined the coral reefs in Singapore to the Southern Islands. Unlike other countries in the region, coral reefs in Singapore are not affected by overfishing or destructive fishing activities (Burke et al., 2002). Direct and indirect effects of coastal development such as land reclamation and high sedimentation rates are the key stresses to the local reefs. While reclamation activities directly bury and kill corals, high sedimentation rates smother corals by blocking out sunlight needed for energy production. Despite the small area of less than 10km^2, the local coral reefs host more than 250 species of hard corals.

Bleaching responses, in which internalized symbiotic zooxanthellae are expelled from the coral host tissue, are indications of environmental stress (Weiss, 2008). This is harmful to host animals because a large source of energy is lost. Bleaching has been most widely

documented in hard corals (e.g., Berkelmans et al., 2004; Eakin, 2010), but also occurs in other marine organisms hosting symbiotic zooxanthellae, including soft corals (Chavanich et al., 2009), sea anemones (Dunn et al., 2002), zoanthids (Kemp et al., 2006) and giant clams (Addessi, 2001).

In affected calcifying marine organisms such as hard corals and giant clams, skeletogenesis and growth are reduced, in the short term likely owing to the physiological response of conserving resources in times of stress, and in the long term due to the assimilation of more thermal-tolerant but less energy-providing symbiont strains (Goreau & Macfarlane, 1990; Tanzil et al., 2009; Manzello, 2010). Because these calcifying organisms form the basic structures of coral reefs, such bleaching events may have severe implications for the future of our coral reef life.

Sea surface temperatures (SSTs) in the Southeast Asian region in 1998 and 2010 rose up to 2°C above the monthly average SST for extended periods (up to three months). Such unusually high SSTs were triggered by a rapid switch from a strong El Niño event to a strong La Niña event (Wang & Zhang, 2002), which was prolonged by the anomalous Philippine Sea anticyclone (PSAC).The sustained elevated SSTs imposed high levels of thermal stress to coral reefs and evoked mass bleaching events of varying scales throughout the region.

The scale and magnitude of bleaching that affected coral reefs worldwide in 1998 were unprecedented. Mortality of shallow water corals was as high as 95% in some parts of the world, although no mortality was recorded on some reefs (Wilkinson & Hodgson, 1999). In Singapore, the bleaching affected most hard coral species and some species of soft corals and colonial sea anemones. Fifty to 90% of all hard corals bleached likely due to the thermal stress. Recovery commenced only when sea surface temperatures returned to normal, and the average bleaching-related coral mortality was estimated at 20% (Tun et al., 1998).In early 2010, SSTs in Southeast Asia exceeded that of 1998, prompting widespread mass bleaching again. The Southeast Asia region experienced bleaching at a severity similar to, or greater than the 1998 event (Tun et al., 2011). In Singapore, 30-60% of hard corals were affected, which was lower than 1998 while the recovery was faster with only less than 10% bleaching-related mortality (Tun et al., 2011).

Fast-growing branching corals *Acropora* and *Pocilliopora* are generally categorized as highly susceptible to thermal stress (Loya et al., 2001; Marshall and Baird, 2000), but both genera were found to be least affected during the 2010 mass bleaching event in Singapore. On the other hand, mortality rates of *Acropora* and *Pocillopora* colonies at Pulau Weh (offshore island north of Sumatra) during the 2010 mass bleaching event were 94% and 87% respectively (Guest et al., 2012). Unlike Singapore which recorded two mass bleaching events in 1998 and 2010, Pulau Weh was not affected by the 1998 bleaching episode. One possible explanation is that the thermally-vulnerable colonies were removed during the 1998 bleaching episode, thus leaving thermally-resistant colonies to reproduce and settle in Singapore reefs (Guest et al., 2012). However, it could also be an acclimatization response of these taxa in Singapore in which more thermally-tolerant symbionts were acquired after the first mass bleaching event in 1998 (Berkelmans & van Oppen, 2006).

Management implications

Elevated SSTs, increased frequency of extreme climatic events, and other climate change-associated phenomena such as sea level rise and ocean acidification are imminent threats not only to the well-being of Singapore's human population, but also to the coastal and marine biodiversity. Habitat degradation and fragmentation for example, which have been driven by

rapid development in the past five decades, may have undermined the ability of marine ecosystems to adapt fully to climate change.

Since climate change is inevitable, the more practical management strategy of habitats would be to mitigate their impacts and encourage local adaptation. Enhancing the already compromised ecosystem resilience is essential to minimising damage from climatic change (SCBD, 2010). Measures such as reduction of anthropogenic pressures and more efficient biodiversity management should be taken. In addition, it is also important to understand and conserve both the genetic diversity and connectivity patterns between habitats. Rich genetic diversity can serve to facilitate ecosystem adaptation and strengthen ecosystem resilience, while a strong connectivity network is required for the natural replenishment of populations in events of environmental disturbances.

Both extreme climatic events described in this paper exposed a serious problem with the lack of monitoring data. In the case of Chek Jawa, there was neither a systematic quantification of the extent of the mass mortality event, nor long-term biodiversity monitoring data available to determine the severity. The mass mortality was first discovered on 1st January 2007, but five months lapsed before any monitoring effort was conducted at Chek Jawa. As a result, crucial information on the extent of damage on the intertidal community, or recovery patterns was not available. The lack of baseline salinity data also restricted any assessments of the intensity of the environmental conditions that the intertidal community was subjected to from December 2006 to January 2007. This would hinder any predictions of the impact of similar events in the future. While there is more information on the mass bleaching events on the coral reefs, crucial SST data was unfortunately not (publicly) available for any in-depth analysis. Sea surface temperatures derived from satellite images could be used as an alternative, however, it is lacking in information on interspatial environmental differences that are not captured due to the low resolution (1 degree x 1 degree) of the data.

The lack of long-term monitoring data on local biodiversity and environmental parameters impedes our deeper understanding of the effects of these climatic events on the ecosystems, and also hampers the development of effective long-term management strategies. These experiences have shown that for any effective coastal management regime, it is essential to establish baseline information, and conduct regular monitoring in order to detect any changes in ecosystems, especially in this era of rapid climate change.

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Coral Reefs in Singapore: Past, Present and Future

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Abstract:

Singapore's hermatypic coral diversity of 255 species represents about one third of the global total. This diversity is despite the loss of about 60% of its coral reefs to coastal development over the past five decades. The remaining coral reefs are exposed to coastal use pressures including sedimentation and live coral cover have declined since the 1980s. The reefs were affected by two major coral bleaching events in 1998 and 2010 linked to the extended periods of thermal stress brought about by ENSO events. Many other zooxanthellate taxa such as soft corals, sea anemones, giant clams, zoanthids and corallimorphs were also affected. On both occasions, recovery from bleaching was reasonably quick. Although the degrees of thermal stress were comparable between 1998 and 2010, bleaching in 2010 was less severe than in 1998. Interestingly, coral taxa that are typically thought to be highly susceptible to thermal stress, such as *Acropora* and *Pocillopora*, were found to be among the least impacted in the 2010 bleaching event. This suggests that some coral species may be able to adapt to higher sea temperatures but equally important is the effort to reduce anthropogenic stresses such as sedimentation and strengthen connectivity between coral reefs.

INTRODUCTION

The pristine condition of Singapore's marine environment was acknowledged by early visitors soon after the island's founding by Sir Stamford Raffles in 1819. Crawfurd (1830) described the superior beauty of the numerous southern offshore islands where most of the coral reefs were located when he sailed through in 1822. Early naturalists including Raffles observed the rich species diversity and discovered coral species totally new to science. The original specimens that were described have since been kept in zoological institutions, especially the British Museum (Chou, 2011). Apart from their scientific value, corals were also exploited for use as construction materials based on evidence of coral fragments retrieved from archaeological excavations. These were likely from fringing reefs on the southwestern coast of the main island. The rate of exploitation in the early days was not intense and the pace of development until the 1960s did not contribute heavily to reef degradation. The condition of the reefs in the 1960s still supported rich and abundant marine life. The clear waters made it possible to see healthy corals thriving in 10-metre depths.

Unregulated collection of reef species for the aquarium trade started in the 1960s and kept pace with increasing demand as the trade developed and peaked in the 1980s. The activity declined after Singapore ratified the Convention on International Trade of Endangered Species in 1986, but the damage is evident from the drop in abundance of many species, particularly reef fishes.

Singapore has since developed into one of the world's busiest ports. Over 150,000 vessel arrivals were registered in 2011 moving 531 million tons of cargo. The port waters occupy more than 80% of the nation's limited territorial waters of about 750 km^2 (Chou, 2006). Berthing infrastructure and wharves dominate the southwestern coastline of the main island. The southern sea is zoned by fairways, anchorages and vessel maneuvering areas that fill the space between the fifty-odd smaller offshore islands with their fringing reefs, scattered mostly in the south.

DEVELOPMENT AND MANAGEMENT CHALLENCES

The pace of development in the coastal and marine environment increased rapidly from the 1960s with mega land-reclamation projects that transformed the coastal seascape. Land reclamation obliterated about 60% of the country's coral reefs (Hilton & Manning, 1995). Coastal development including the dredging of shipping lanes and the dumping of earth spoils, which were implemented without impact assessments until the late 1990s. These activities introduced a high volume of sediment to the sea, reducing water visibility from ten metres in the 1960s to a metre today. Reefs that escaped reclamation are however subjected to the impact of heavy sedimentation. Sedimentation retards coral growth by smothering and most importantly by reducing sunlight penetration.

The port waters are stringently managed to ensure safe shipping and prevent accidents that cause spillage of oil and hazardous chemicals. Despite these safeguards, risks remain, evident from the list of incidents that occurred between 1996 and 2006 (Tan *et al*, 2007). In October 1997, two oil tankers, the "Evoikos" and the "Orapin Global" collided in the Singapore Strait releasing 28,500 tonnes of oil, the largest spill in Singapore's history. The oil impacted the inter-tidal reef flat but not the sub-tidal reef slope. Coastal reclamation and seabed dredging alters hydrodynamic

patterns while high speed vessels generate fast waves that scour reef flats and exposed shores. Grounding of flat-bottom barges on reef flats leave large tracts of damaged corals. All these activities have an impact on coral reef biodiversity.

Today, most of Singapore's reefs fringe the southern offshore islands. Reefs along the mainland have been totally eliminated, except for a small reef community at Labrador beach. There are also a few good reef communities associated with the northeast offshore islands. Although the abundance of many species is depressed, species elimination is not that evident. Of the 255 species of hard coral recorded from the reefs (Huang *et al*, 2009), only two can by now be confirmed as locally extinct. Other reef-associated animals like seashells, giant clams, sea cucumbers and sea stars are also less commonly found because of habitat loss, degradation and the earlier unregulated exploitation.

CORAL REEF BIODIVERSITY STATUS

Exposed to the diversity of impacts, Singapore's coral reefs face three major threats: habitat loss, habitat degradation and habitat modification. Historical records depict a rich biodiversity (Chou, 1994) and despite the varied and persistent impacts, new records of species not previously known to occur are still being made today. This is easily explained by the lack of exhaustive taxonomic investigations due to the difficulty of engaging experts. Taxonomic groups such as reef fishes and molluscs that were historically well documented give reliable records of past biodiversity, and impact assessments can be deduced from what has since been lost. For most groups that were well studied in the past, the indications are little to no decline in species richness, but an evident depreciation of abundance.

The general trend for reef biodiversity is that while species elimination is less than expected, the frequency of occurrence and abundance of many species have been much reduced (Chou, 2006). The high species diversity of hard corals represent almost one third of the global coral diversity. This is significant considering the limited extent of the country's reef area, estimated to be less than ten km^2.

At the same time, newly created habitats from coastal development continue to provide an alternative environment for marine species, although the new conditions may favour other species over those that thrived in the original habitat. Southeast Asia is recognized as the global centre of marine biodiversity and Singapore's location entitles it a fair share of this rich heritage. A healthy species list however, does not provide a guarantee against biological richness decline. While marine species extinctions are less compared to terrestrial species, they have occurred and biodiversity conservation remains as important for marine species.

Most of Singapore's coral reefs at present exist as patch reefs (associated with a raised sea bottom) or fringing reefs around the southern islands. The extensive fringing reef flats of some of the larger islands were reclaimed or transformed into swimming lagoons. Until the 1970s, fringing reefs were present on the main island but they have all been buried by coastal reclamation. Apart from the southern offshore reefs, a few are present at the northeast offshore islands. The past decades of increased sedimentation resulted in loss of coral from below six metres of the reef slope and an average 34% reduction in live coral cover from the upper slope.

Coral growth is now compressed within the upper reef slope with the reef crest supporting the best reef development.

The coral community is presently dominated by foliose growth forms, which have suitably large surface area to capture as much as possible of the reduced solar energy. Branching *Acropora* corals, which dominate reefs of the region, is now uncommon in Singapore reefs because of past harvesting pressure and present environmental impacts. The intertidal reef flat supports species that can tolerate periods of exposure, examples of which are *Favia*, *Favites*, *Goniastrea*, *Platygyra*, and *Oulastrea*. The greatest coral diversity occurs on the reef crest and large colonies of *Porites*, *Diploastrea* and *Symphyllia* are present. *Pectinia*, *Turbinaria* and *Pachyseris*, which all exhibit foliose or laminar growth forms dominate the lower reef slope. Their large surface area allows them to optimise the available low light energy.

Macroalgae such as the mermaid's fan (*Padina* species), and *Halimeda* species, are abundant throughout the reef flat. The brown seaweed, *Sargassum* grows vigorously as thick bushy stands at the reef crest, breaking loose during the monsoons. Reef biodiversity includes a full spectrum of reef-associated species like soft corals, sponges, hydroids, sea fans, and an entire assortment of molluscs, crustaceans, echinoderms, protochordates and fishes. Three species of giant clams are known, *Tridacna squamosa*, *Tridacna crocea* and *Hippopus hippopus*, but their populations have declined considerably.

CLIMATE CHANGE IMPACTS

Unusual sea surface temperature elevation associated with the El Niño Southern Oscillation (ENSO) events in 1998 and 2010 affected Singapore's coral reefs on a wide scale and presented a new management challenge. In early 1998, elevated sea temperature resulted in mass bleaching of Singapore corals at a scale previously unknown. More than 90% of all corals bleached and up to 20% failed to recover after sea temperature returned to normal. In 2010, another large-scale coral bleaching occurred in response to elevated sea surface temperature, resulting in up to 10% mortality. However, differences in species mortality patterns were observed (Guest *et al*, 2012) where species that were badly affected in the 1998 event appear to be less affected in 2010 and vice versa.

Despite all these impacts, important biological processes are kept intact. Mass spawning events where many coral species synchronously release eggs and sperm or fertilized egg bundles, occur consistently during the April full moon (Guest *et al*., 2002). This is followed by a smaller event in September or October and timed to coincide with the inter-monsoon lull to improve larval survival. The pomacentrid fish species also spawn during the inter-monsoon periods (Low *et al.*, 1997).

THE FUTURE OF SINGAPORE'S CORAL REEFS

No comprehensive reef biodiversity assessments have been conducted, although long-term monitoring since 1986 indicated an overall decline in live coral cover as well as a reduction in the abundance of reef-associated invertebrates, and some isolated studies over the past three decades focused on specific faunal groups. The present coral community structure is influenced by sedimentation impacts and is dominated by foliose growth forms, which have suitably large surface area to capture as much as possible of the reduced sunlight energy.

A number of artificial reef and reef restoration projects have been initiated (Tan *et al*., 2007) and a coral nursery was established off Pulau Semakau in 2007 (Wong, 2007). The latter makes use of naturally-fragmented corals from reefs and growing them at the nursery to enhance survival and growth. On the whole, in spite of reef loss and all the impacts, species richness stays comparable with reefs in the surrounding region.

The present approach, where development takes precedence over conservation, has not resulted in drastic depletion of marine biodiversity. Newly-created and modified habitats continue to support life. Species extinction from Singapore waters is not high, as many are redistributed by the changing seascape. Ecosystem processes have not been completely overwhelmed. Seasonal mass spawning of corals, recruitment and growth patterns of other marine species all indicate that biological processes are still intact. It is therefore completely possible for port waters to be teeming with marine life and rich habitats for as long as water quality is maintained. In return, the environmental services provided by a high biodiversity will help to reduce environmental renewal costs (Chou, 2008). In this era of climatic changes, it is even more important to focus attention on the protection of marine living resources in order to minimize unnecessary anthropogenic damage and loss, as these can exacerbate the effects of climate change on the local reefs. Integrated management and strategic impact assessment are approaches relevant to Singapore's situation, with its limited but intensively used marine territory.

None of the coral reefs in the southern offshore islands are under legal protection, and the lack of an integrated coastal management mechanism has resulted in the low priority given to the protection of marine habitats until the turn of the century. The establishment of the Biodiversity Centre by National Park Board in 1994 and the expansion of its mandate to cover the marine environment has started to address the previous limitation. At the same time, the formation of an inter-Ministerial Technical Committee on Coastal and Marine Environment in 2007 with representatives from all relevant agencies provided a framework that would support an integrated management approach.

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Solid-Phase Trapping System for Supercritical Fluid Extraction on Determination of Microbial Quinones

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Abstract:

Quinone profile is one of the methods in microbial community analysis. In previous work, the extraction of microbial quinones from environmental samples was performed with methanol modified supercritical carbon dioxide ($scCO_2$), followed by fractionation. The quinones were quantified using high pressure liquid chromatography. This method proved to be a potential alternative to conventional organic solvent extraction method. In the present work, microbial quinones were determined by supercritical fluid extraction (SFE) and octadecyl silica (ODS) solid-phase trapping system followed by quantification using ultra performance liquid chromatography (UPLC).

The experiments were performed as follows: sample containing quinones were extracted with methanol modified $scCO_2$ followed by trapping of the quinones in ODS solid-phase. Then, the solid-phase containing quinones were eluted out from ODS solid-phase with a mixture of diethyl ether and hexane. Finally, the eluent containing quinones were quantified using UPLC. SFE experiments were performed at a temperature of 45 ^{0}C, a pressure of 25 MPa.

The results showed that quinones could be trapped on ODS solid-phase. The best result was achieved when 400 μL of methanol was added at a static time of 5 minutes, a total fluid flow rate of 2 mL/min, and a dynamic time of 10 minutes. This system could simplify the procedure with reduction of one-fourth of time needed and more than 90% of solvent usage compare to the conventional solvent extraction method. Further studies are in progress to improve this method as an effective technique for determination of microbial quinones in environmental samples with extended the automation.

I. INTRODUCTION

Quinone profiling method has gained increased recognition as a simple and useful tool for the characterization of different microbial communities in natural environments. This method has been successfully developed for analysis of microbial community structure in various fields such as wastewater treatment (Hiraishi, 1988; Fujie, *et al.*, 1994), natural aquatic systems (Wang, *et al.*, 2011), hot springs (Hiraishi, *et al.*, 1999), soil (Watzinger *et al.*, 2008), composting (Yu, *et al.*, 2007; Yoshida and Katayama, 2004) and bioremediation (Kunihiro *at al.*, 2008).

Quinones are membrane-bound compounds found in nearly all living organisms and their function are mainly as an electron and proton carriers in photosynthetic and respiratory electron transport chains (Nowicka and Kruk, 2010). In general, one species of bacteria has only one dominant type of quinones (Hiraishi, 1999). Quinone profile is usually represented as the mole fraction of each quinones type, which means that the quinones profile should specific for a microbial community. Therefore, changes in a microbial community structure in a mixed culture of microbes from various environmental samples could easily be analyzed using the quinone profile (Hu *et al.*, 1999).

Microbial quinones classified into two major groups: the ubiquinones (1 -methyl-2-isoprenyl-3,4-dimethoxyparabenzoquinone) and menaquinones (1-isoprenyl-2-methyl-naphtho-quinone). Ubiquinones as well as menaquinones are named according to number (n) of isoprene units and the degree of hydrogenation in the side chain (x), and are abbreviated as UQ-n(H_x) and MK-n(H_x), respectively. For example, UQ-10 represents a ubiquinone with 10 isoprene units in its side chain, and MK-9(H_2) shows a menaquinone with 9 isoprene units in its side chain and one of the double bonds in the side chain is saturated with two hydrogen atoms (Hiraishi, 1999; Hu *et al*., 2001).

Monitoring of microbial community requires simple and rapid analysis routine analysis. Therefore, microbial quinones were extracted by supercritical fluid extraction (SFE) followed by fractionation and identification of the quinones using high performance liquid chromatography (HPLC) (Irvan 2006a, Irvan *et al*., 2006b) or ultra-performance liquid chromatography UPLC (Hanif *et al*., 2012a; Hanif *et al*., 2012b). This method has advantages over conventional organic solvent extraction method in term of rapidity, simplicity, selectivity and low solvent volume usage. Moreover, supercritical fluid extraction (SFE) using carbon dioxide (CO_2) has been recognized as a green technology (Deshpande *et al*., 2011). Therefore, the use of SFE to replace conventional organic solvent is promising.

Application of the solid-phase trapping of neutral lipid was demonstrated to collect the extracted microbial quinones in the SFE system (Hanif et al., 2012a). This previous research developed a more effective analysis method of directly mounting the solid-phase extraction cartridge in-line on the SFE instrument. Sep-Pak® Plus C18 ODS cartridges was used as a solid-phase trapping media to this in-line system. It was demonstrated that identification of trapped quinone with UPLC is possible without further purification. This result showed that ODS trapping cartridge has potential to be used as an interface to liquid chromatography (LC) from SFE for quinones analysis. Therefore, the aim of this study is to investigate the use of ODS in solid-phase trapping system for collection of extracted quinones after SFE. In this system, after collecting the extracted quinones, the ODS solid-phase trap is transferred manually to HPLC equipment for online analysis. Instead of dynamic mode of SFE (Hanif, *et al*., 2012a), as conducted in our previous work, this present work was performed by static-

dynamic mode where methanol was also added directly to the matrix sample for enhancing solubility of quinones. Applicability of ODS solid-phase as trapping media in the static - dynamic mode of SFE was demonstrated.

2. MATERALS AND METHODS

2.1 Chemicals and Solid-phase Trap

Chemical standard for both ubiquinone-10 (UQ-10) and menaquine-7 (MK-7) were purchased from Nacalai Tesque (Kyoto, Japan). Acetone, methanol, di-isopropyl ether and hexane were HPLC grade obtained from Wako (Osaka, Japan). Standard stock solution of UQ-10 and MK-7 were prepared in acetone at a concentration of 1,0 mmol/L and 0.5 mmol/L, respectively and stored in a brown-glass vial at -20 ^{0}C. Solid-phase trap used in this study was octadecyl-silica cartridge (Zorbax-ODS 4.6 mm I.D. x 12.5 mm x 5 µm, Agilent Technologies, Santa Clara, CA, USA). For fractionation purpose to SFE without trapping method, Sep-Pak® Plus Silica cartridges (1 cm I.D x 2 cm; polypropylene tubes; silica gel content: 600 mg; particle diameter: 55–105 µm) was used and purchased from Waters (Milford, MA, USA).

2.2 Sample Preparation

The digested sludge sample was taken from an anaerobic pilot plant of Maezawa Industries Co. Ltd., Japan, treating a mixture of cow manure and food waste. Prior to quinone extractions experiments, the sludge sample was dried for 24 h in vacuum-freeze-dryer then crushed and sieved to collect particles smaller than 500 µm. Approximately 100 mg of the freeze dried sample was used for all experiments.

2.3 Analytical Steps

Analytical steps of supercritical fluid extraction (SFE) on the determination of microbial quinones were done as shown on Figure 1. There were two analytical methods: SFE with solid-phase trap and SFE without trap method. In the first method, ODS solid-phase trap was used to collect extracted microbial quinones by online system to the SFE. The trap then transfer manually to HPLC for quinones analysis as shown in Figure 2. To compare the extraction efficiency of the first method, SFE without trap method was done. In this second method, no solid-phase trap was used to collect the extracted microbial quinones. After the SFE, the extracted quinones then purified and fractioned before performing the quinones analysis by a typical of liquid chromatography (LC), UPLC.

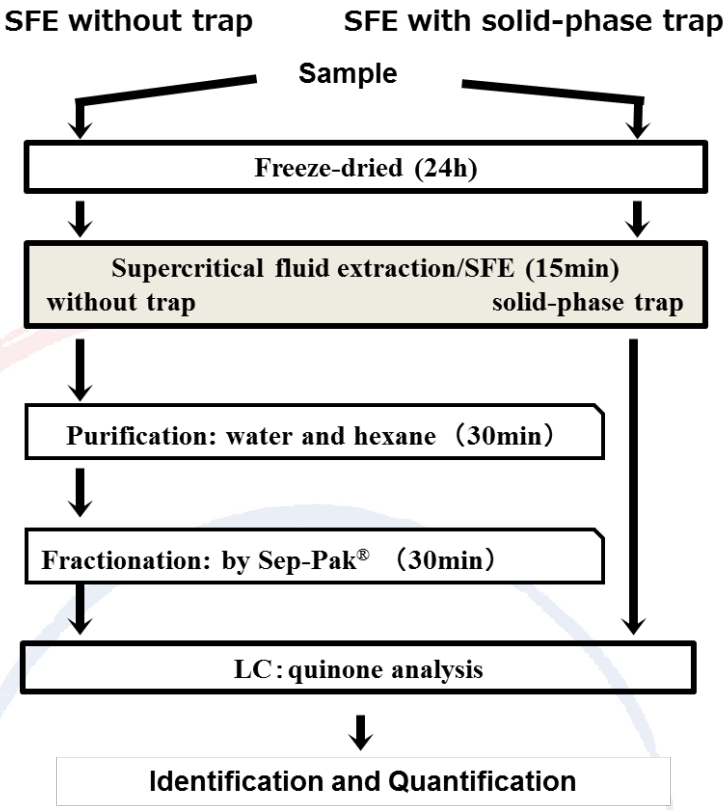

Figure 1 Analytical steps of the SFE with solid-phase trap and SFE without trap method.

2.4 Supercritical Fluid Extraction

Figure 2 shows a schematic diagram of SFE-solid-phase method used in the present study. The system mainly consisted of an oven (GL Sciences GC-353B oven, Tokyo, Japan) equipped with an extraction vessel (1 mL internal volume, SUS 316.47 mm long, 10 mm I.D.), a backpressure regulator (Jasco-BPG 880-81, Tokyo Japan) used to control the pressure and a high-pressure pump: Jasco PU-1580 HPLC pump (Tokyo, Japan) used to deliver CO_2. Besides, a solid-phase trap (octadecyl-silica cartridge, Zorbax-ODS 4.6 mm I.D. x 12.5 mm x 5 µm, Agilent Technologies, Santa Clara,CA, USA) was directly mounted to the SFE system to collect the extracted microbial quinones.

In the SFE with solid-phase trap method, effects of static-dynamic extraction were studied. Approximately 100 mg of sample (freeze-dried digested sludge sample) was filled into the extraction vessel. After that, methanol – as a modifier – at various volumes (200 µL, 300 µL, 400 µL, or 500 µL) was also added directly onto the sample inside to the vessel. The sample was then extracted by supercritical CO_2 in static mode where pressure and temperature of extraction vessel were 25 MPa and 45 ^{0}C, respectively. After 5 or 10 minutes of static extraction time, the extracted microbial quinones were flushed from the vessel by the supercritical CO_2 at a flow rate of 3 mL/min for 5 min, passed through to backpressure regulator (restrictor), and collected to the ODS solid-phase trap. The trap containing extracted microbial qinones then transferred manually to HPLC for quinones analysis.

The effect of dynamic extraction time was performed by adding 400 µL of methanol as a modifier to the sample followed by extracting the sample for 10 min in static mode at a condition as describe above. After that, the extraction was continued by flowing supercritical

CO_2 at a flow rate of 1-3 mL/min. During the extraction, extracted quinones were also collected in the ODS solid-phase trap. The extraction was terminated after 5 or 10 minutes witch were designed as the dynamic extraction time. The trap then transferred manually to HPLC for quinones analysis.

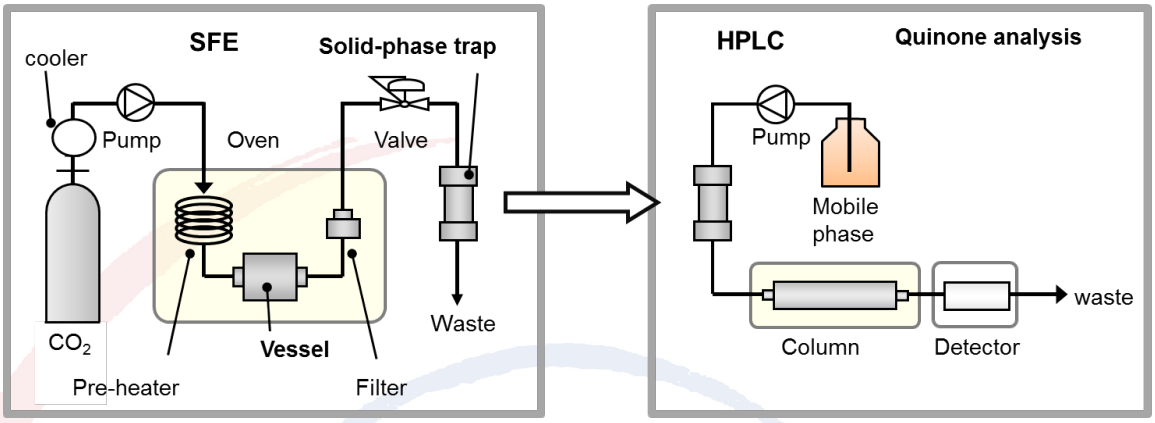

Figure 2 Schematic diagram of the solid-phase trapping system for supercritical carbon dioxide extraction used in the present study.

As a comparison to SFE with solid-phase trap method, SFE without trap method was also performed without trap as describe elsewhere (Hanif *et al.*, 2012a). The sample was extracted by SFE at a condition as follows: an extraction vessel temperature of 55^{0}C, a pressure of 25 MPa, a CO_2 flow rate of 2.7 mL/min, and a methanol flow rate (as a modifier) of 0.3 mL/min for 15min. An empty vessel was used to collect the extracted microbial quinones in the SFE system. The extracted quinones then purified and fractioned as described by Gao *et al.* (2003). The quinones were then analyzed by UPLC.

The extraction efficiency of SFE with solid-phase trap method compared to SFE without trap method was calculated as shown by equation (1).

$$Extraction\ efficiency\ (\%) = \frac{\text{M with solid-phase trap}}{\text{M without trap}} \text{ x } 100\% \quad \text{.....(1)}$$

where $M_{\text{with solip-phase trap}}$ is the total amount of quinones in µmole/g-dry-sample obtained by SFE with solid-phase trap method, $M_{\text{without trap}}$ is the total amount of quinones in µmole/g-dry-sample obtained by SFE without trap method.

2.5 Liquid Chromatography (LC) Analysis

Extracted microbial quinones were analyzed by HPLC or UPLC. In the SFE with solid-phase trap method, the solid-phase trap was transferred and attached to HPLC as an online system as shown on Figure 2. The mobile phase passed through to the trap, eluted the microbial quinone on the trap, followed by separation of the quinones in the column and identified the quinone species on the detector. The HPLC (Shimadzu, Japan) was equipped with an ODS column (Zorbax-ODS, 4.6 mm I.D.x 250 mm, Agilent Technologies, Santa Clara,CA, USA) and a photo diode array detector (SPD-M10A, Shimadzu, Japan). The temperature of column oven was set at 35 ^{0}C. The mobile phase was a mixture of methanol and isopropyl ether (9:2, v/v) at a flow rate of 1.0 mL/min.

For UPLC analysis, the extracted microbial quinones were analyzed using UPLC (Water Acquity system, Milford, MA, USA) equipped with a binary solvent delivery manager, a sample manager and a photo-diode array detector (PDA-2996, Water), and an analytical column (Waters Acquity UPLC^{TM} BEH C18 column, 1.7µm, 2.1mmx50mm). The mobile phase was 100% methanol and pumped to the column at a flow rate of 0.5 mL/min. Sample injection volume was 10 µL and the auto-sampler temperature was set at 40 ± 1 ^{0}C. All analyses were performed at a column temperature of 35±1 ^{0}C with a chromatographic run time of 35 min. At this column temperature and the mobile flow rate, separation was achieved in 10 min with a backpressure of 8,000 psi.

Quinone species detected by HPLC or UPLC were identified base on the retention time on the column and spectrum of each peak observed in the detector. The linear relationship between the logarithm of the retention times of quinones and the equivalent number of isoprenoid unit (ENIU) was also used to identify the quinone species (Hasanuddin *et al.*, 2004; Katayama and Fujie, 2000). The amounts of quinone species were calculated based on peak area and molar absorption coefficient of the quinones (ubiquinones 14,4 $mM^{-1}cm^{-1}$, menaquinones 17.4 $mM^{-1}cm^{-1}$) (Kroger 1978).

3. RESULTS AND DISCUSSION

The use of ODS solid-phase trap was evaluated as trapping media to collect extracted quinones after SFE. The SFE with solip-phase trap experiments were performed in static-dynamic mode. The effect of different operational parameters (e.g., static extraction time and dynamic extraction time) on extraction efficiency was studied. The extraction efficiency was calculated based on the extracted quinones amount obtained by SFE with solid-phase trap method compared to quinones amount obtained by the SFE without trap method.

1.1 The Effect of Static Extraction Time and Injection Volume of Methanol as a Modifier

The effect of static extraction time and methanol as a modifier was evaluated to the extraction efficiency of quinones in ODS solid-phase trap. Figure 3 shows the extraction efficiency of SFE with solid-phase trap at 5 min or 10 min of static extraction time and at various injection volumes of methanol as a modifier. At 5 min static extraction time, the highest extraction efficiency was obtained when 400 µL of methanol was added as a modifier to the sample. There was no significant increase when 500 µL of methanol was added to the sample and there was no effect at all when 200 µL and 300 µL of methanol were added. On the contrary, at 10 min of static extraction time, the extraction efficiency increased by increasing of methanol addition until reached a maximum efficiency of 91 % at an addition of 400 µL. However, the efficiency decreased when 500 µL was added to the sample.

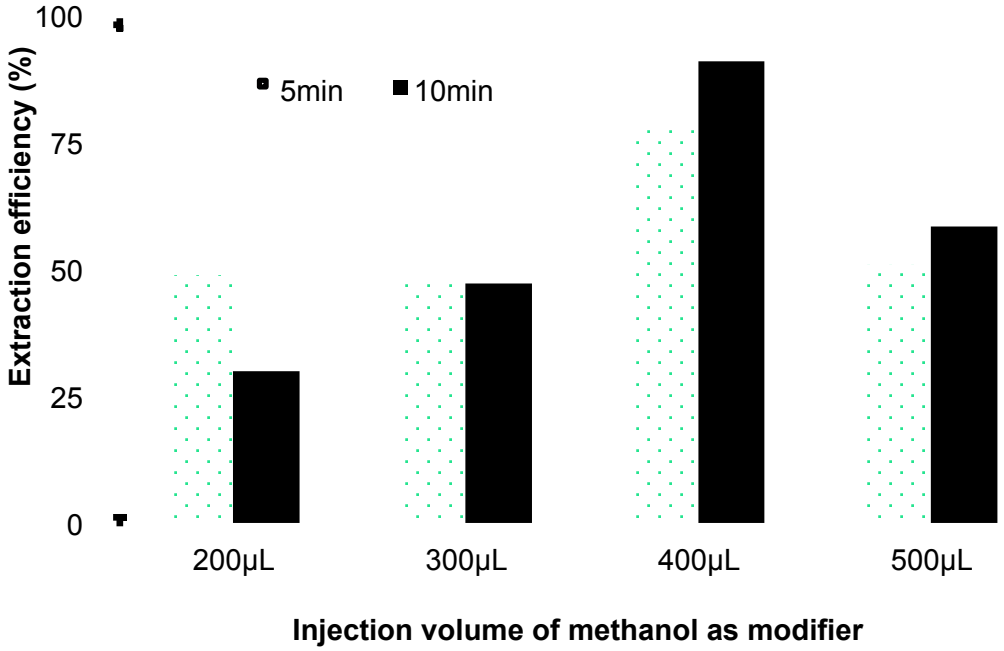

Figure 3 Extraction efficiency of SFE with solid-phase trap compared to SFE without trap method at various static extraction times and injection volumes of modifier.

When static extraction time was increased from 5 min to 10 min, extraction efficiency was increased by 16% at a modifier volume of 400 µL. However, no significant effect could be observed to other modifier volumes. It was reported that static extraction time influenced the extraction efficiency (Lehotaya ang Valverde-Garcia, 1997). The time was required to allow extraction fluid to fully penetrate the sample and dissolve the analyte. In the current study (Figure 3), a significant effect only could be observed at an addition volume of 400 µL. These results show the applicability of SFE with solid-phase trap using ODS. Based on these results, it could be decided that addition modifier of 400 µL at 10 min static extraction time gave the best result amount others. These operation parameters were used for further study.

1.2 Effect of Dynamic Extraction Time and Supercritical Flow Rate of CO_2

Instead of dynamic mode of SFE as performed in our previous works (Irvan *et al.*, 2006a; Irvan 2006b; Hanif *et al.*, 2012a; Hanif *et al.*, 2012b), in this work, a static-dynamic mode was performed. The effect of dynamic extraction time (1-15 min) and supercritical flow rate of CO_2 (1-3 mL/min) were shown in Figure 4. At a flow rate of 2 mL/min and 3 mL/min, increasing dynamic extraction times were increased the extraction efficiency. When the dynamic extraction time was increased to 10 min, extraction efficiency reached maximum value of 66% and 109% for flow rate of 2mL/min and 3 mL/min, respectively. However, at a flow rate of 1 mL/min, the maximum value of 100% occurred faster, *i.e.* at a dynamic extraction of 5 min. In all experiments, after reaching a maximum value, increasing dynamic extraction times were decreased extraction efficiency. This decrease was probably caused by a decrease in trapping efficiency due to saturation of the ODS solid-phase trap with a modifier (methanol) (Nemoto *et al.*, 1997; Mulchahey and Taylor, 1992; Howard and Taylor, 1993). On ODS solid-phase trap with methanol, trapping efficiency increased by increasing

the methanol volume until a certain volume of methanol, then the efficiency decreased when methanol volume was increased due to saturation.

It was demonstrated that at a dynamic extraction time of 10 min, the extraction efficiency reached a maximum value that was higher than 100 %. It means that quinones could be extracted and trapped using ODS solid-phase trap and this trapping system showed a better quinones recovery compared than that of without trapping system. Based on the results of those operating parameters, the optimum conditions were at a static extraction time of 10 min, an addition of methanol as a modifier of 400 µL, a dynamic extraction time of 10 min and a CO_2 flow rate of 2 mL/min.

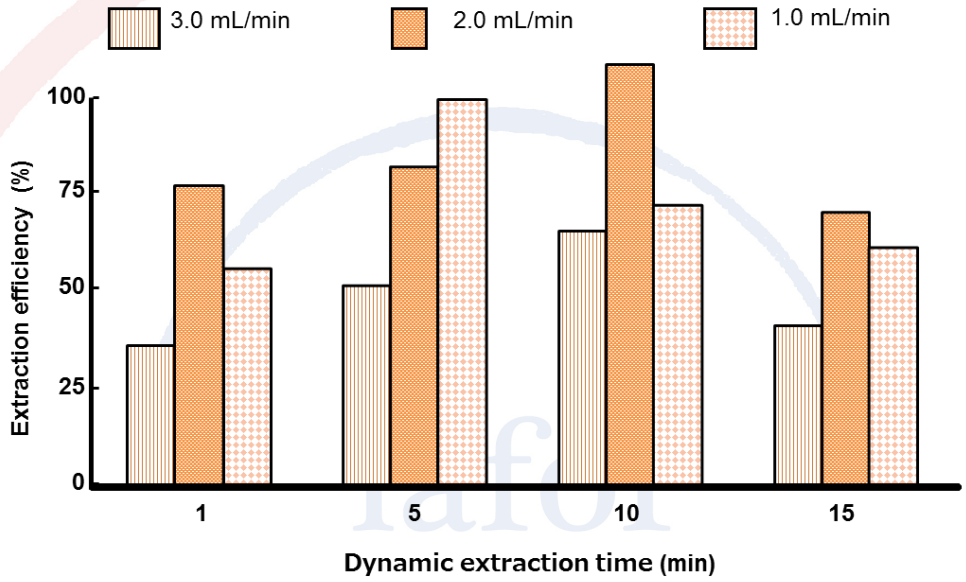

Figure 4 Extraction efficiency of SFE with solid-phase trap method compared to the SFE without trap method at various dynamic extraction times and supercritical flow rate of CO_2.

1.3 Comparison of SFE with solid-phase trap method to SFE without trap method

The quinone content obtained by the SFE with solid-phase trap was compared to the SFE without trap method. The SFE with solid-phase trap method was carried out at an optimum condition as previously determined (static extraction time, addition of methanol as a modifier, dynamic extraction time and CO_2 flow rate were 10 min, 400 µL, 10 min and 2 mL/min, respectively). The results are shown in Figure 5. Three types of ubiquinones (UQ-8, UQ-9 and UQ-10) and eight types of menaquinones were identified based on the retention time and the molar absorption coefficient. The same type and number of quinones were identified using the two methods. The most dominant of bacterial quinones from the digested sludge samples were MK-7, MK-8(H_2), UQ-9, MK-5(H_2), MK-9(H_2). The total amount of extracted quinones by SFE with solid-phase trap and SFE without trap method were 75.17 µmol/kg-dry-sample and 68.85 µmol/kg-dry-sample, respectively. It means the recovery of total quinones obtained by SFE with solid-phase trap method was higher than that of SFE witout trap method. In addition, the time required to extract and analyze the samples 2 times faster (1.5 h) than that of the SFE witout trap method (more than 3 h). The solvent required was also 3 times smaller (60 mL) than that of SFE without trap method (195 mL). Based on these

results, it can be concluded that the SFE with solid-phase trap can replace the SFE without trap method.

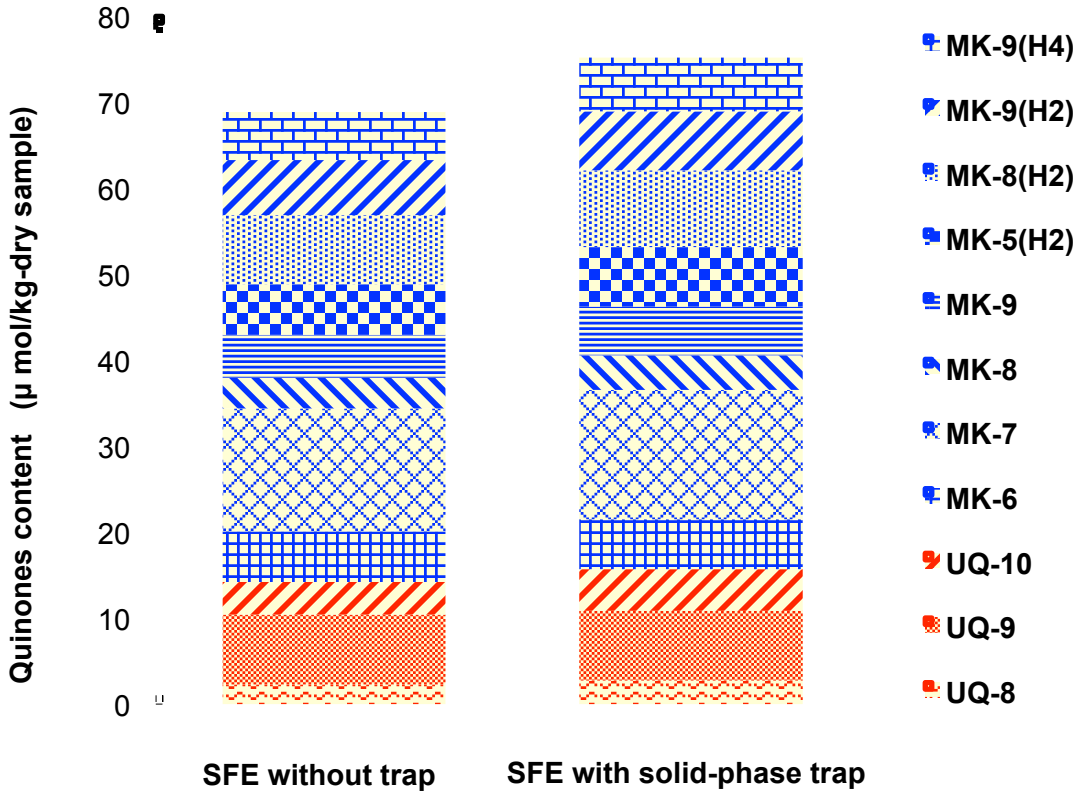

Figure 5 Comparison of SFE-solid-phase trap method to SFE+UPLC method.

4. CONCLUSIONS

It was demonstrated that ODS solid-phase trap (Zorbax-ODS) could be used as trapping media to collect microbial quinones after SFE. This method performed an online system of SFE extraction to HPLC analysis for determination of microbial quinones from digested sludge sample. Recovery of quinones obtained by SFE with solid-phase trap method was higher than that of SFE without trap method. In SFE with solid-phase trap method, the time and solvent amount required to determine microbial quines were shorter and smaller compared to SFE without trap method, respectively. The SFE with solid-phase trap method was simpler and stepped ahead compared to our previous works in term of extended to possibilities of automation in application for analyzing of microbial quinones in environmental samples.

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