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Treatment of Wastewater Contaminated with Water-Based Varnish and Glue Using Wasted Chemical and Materials in Coating/Lamination Plant

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Abstract

Vanish coating or film lamination is usually applied to protect the surface and add the value of printed products. Water-based coatings and water-based glues have become popular because of their environmental friendly and non-harmful properties. However, they caused wastewater from machine washing to be treated before discharge. The objectives of this research were to survey the sources of effluent in a coating/lamination plant and to find the proper technique of wastewater treatment. The effluent contaminated with water-based varnish and glue were mixed to determine the results of coagulation/flocculation using the wasted coagulant and materials. The results showed that 50 L of wastewater could be treated by adding 250 mL of wasted ferric chloride solution and stirring for 2 minute before leaving for sedimentation. The sludge was separated by filtering with the wasted mesh cloth and dried by sun. The residual color of water was further removed through the adsorption column packing with the granular activated carbon. The water qualities were detected for chemical oxygen demand (COD), total dissolved solids (TDS), suspended solids (SS) and pH value. After coagulation process, COD, TDS and SS values were reduced from 58,902, 30,424 and 772 mg/L to 7,384, 3,192 and 54 mg/L, respectively. After adsorption process, COD, TDS and SS values were further reduced to 23, 597.3 and 6.6 mg/L, respectively. The pH value was decreased from 7.6 to 5 by coagulation but it was increased to 7.13 after adsorption. The qualities of treated water were acceptable under standard criterion of Thai industrial effluent.

Keywords: Adsorption/ Coagulation/ Wastewater/ Water-based glue/ Water-based vanish

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Introduction

Varnish coating on fiber materials can provide adequate protection from water vapor diffusion for a certain period of time and add the value of printed products. Waterbased coating (dispersion varnish) are more prone to penetrate fibrous substrates such as paper, cardboard or corrugated board. The aqueous coating which is polymer dispersed in water dry physically by absorption into the absorbent substrates and evaporation of water through hot air and infrared to form the film over the surface. Water-based coatings have become popular in the printing industry especially for food, healthy and pharmaceutical packaging due to environmentally friendly, nontoxic and odorless (Thomas, 2013). In addition, absolute protection can be achieved by using film-laminated materials by overlay a layer of plastic film on substrate by the application of adhesives and pressure to improves strength, stability, gloss, matt and water/moisture resistance. The water-based glue is also usually applied in wet lamination to bond the plastic layer over the fibrous substrates. The inner lamination of the paper packaging also improve barrier or permeation properties to preserve the consumer products. Although the water-based varnish or glue containing disperse polymers and other water soluble additives are non-harmful and safety, it may cause high volume of wastewater due to the machine cleaning/washing with water after coating/lamination process.

The effluents contaminating with either varnishes or glues are much turbidity with high level of Chemical Oxygen Demand (COD), which must be removed before being discharged to impact the environment and ecology of stream. Coagulation-Flocculation is a common process to treat industrial wastewater in order to remove suspended particles from water. Most solids suspended in wastewater generally possess a negative charge; they consequently repel each other to prevent agglomerating. Many studies showed that the contaminant particles were removed from wastewater by mean of coagulation process using cationic coagulants such as ferrous sulfate, ferric chloride, alum, PAC, lime and polyelectrolyte (Asilian et al, 2006). The usage of commercial coagulants will increase cost of wastewater treatment process in many plants. In this study, the low-cost wastewater treatment was determined by utilizing the wasted materials in a coating/lamination plant which will be a good solution to manage their waste and wastewater. In the coating/lamination plant, there are many special effect coatings such as texture coating and spot coating. For texture coating, the embossing metal plate was made by chemical etching with ferric chloride acidic solution which might be reused as a low-cost coagulant for wastewater treatment. The treated water could be separated from the sludge by filtration using mesh cloth which was the wasted from making the screen plate used for spot coating. The residual color in water could be further removed by the adsorption process using the granular activated carbon (GAC) as economic adsorbent (Islam, A. 2013). The objective was to find the proper low-cost technique for wastewater treatment of the coating/lamination plants by utilizing their wasted materials.

Experimental

Survey of wastewater and collection of sample for coagulation batch test

The volume of wastewater was consider every day in 3 weeks and compared between 2 sources of effluent; coating machine washing (A) and lamination machine washing (B). The samples of effluent A containing water-based varnish and effluent B containing water-based glue in 1 L a week was then collected for coagulation batch test. Three types of wastewater contaminated with varnish, glue and mixture of varnish and glue were added with 1.2% (v/v) of ferric chloride solution and stirred for 2 minutes before leaving overnight. The efficiency of coagulation, flocculation and sedimentation of the samples were observed and compared.

Determination of effluent mixing ratio and coagulant dose in batch test

The optimum ratio of effluent mixing was also studied from 3 mixing ratio in volume of effluent A and B at 50:50, 70:30 and 80:20, respectively. Three lots of different wastewater samples collected from each 3 weeks were studied for the coagulation batch test using 1.2% (v/v) of ferric chloride solution. The sludge from sedimentation was separated by filtering with mesh cloth No. 200 or 75 µm openings. The pH values of wastewater and treated water, the reaction change, the settling time and the amount of sludge were analyzed. The wastewater mixed from effluent A and effluent B with an optimum ratio was then further studied using various dose of ferric chloride solution; 0.5%, 1%, 1.5%, 2% and 2.5% (v/v) respectively.

Designation of real large-scale wastewater treatment system

The coagulation/flocculation tank was designed using corrosion resistant stainless steel with the inner volume of 60 L. The radial impeller was used as agitator for mixing the coagulant dispersed throughout the water quickly. The cone-shape bottom also performs as a settling tank for sludge leaving by gravity. The sludge was discharged from the tank outlet and the treated water at upper level was flown to the adsorption column of granular activated carbon (GAC) with the inner volume of 100 L. The GAC was also used for air adsorption filter to separate gaseous harmful substances and odor in the plant. The mixture of 50 L wastewater from 2 sources was agitated for 5 minutes before adding with optimum dosage of ferric chloride solution and agitating for 2 minutes. After leaving overnight for settling, the sludge was separated by filtering, and the parameters of treated water were analyzed such as chemical oxygen demand (COD), total dissolved solids (TDS), suspended solids (SS), pH value and color.

Results and Discussion

Sources and volume of effluents from the coating/lamination plant

The volumes of effluent from 2 sources; coating machine washing (A) and lamination machine washing (B) were compared before consideration of wastewater treatment. Figure 1 indicates that the volumes of effluent containing water-based varnishes (A) were much more than that of effluent containing water-based glue (B) in every weeks.



Figure 1: Volume of effluents from 2 sources in the plant for 3 weeks

Optimum wastewater mixing ratio and coagulant dose in batch test

The preliminary tested for coagulation using 1.2% (v/v) of ferric chloride solution showed that the effluent B and the effluent A+B had good flocculation. Their suspended particles rapidly formed to agglomerate into masses large enough to settle or be filtered from water while the flocculation of effluent A was not good enough, as shown in Figure 2.



Figure 2: Effluent A, B and A+B before and after coagulation of wastewater

The glue contaminated in effluent B might reacted as an organic coagulant to enhance the agglomeration of particles, indicating that the wastewater from 2 sources should be mixed before treatment. Since the volume of effluent A was usually much more than effluent B and the volume of each week was not stable, the optimum ratio of effluent mixing was also studied. The results of various mixing ratio of effluents A and B in coagulation batch test were shown in Table 1.

Table 1: Coagulation/Flocculation results for different ratio (%) of effluent mixing.

Results	A:B at 50:50	A:B at 70:30	A:B at 80:20
Initial pH value	7	7	7
Color after coagulation	Yellowish	Dark Brownish	Dark Brownish

Final pH value	4-5	4-5	4-5
Flocculation	good	Not good	Not good
Settling time (min)	1-3	4-5	4-5
Sludge weight (g/L)	16.4 - 23.2	16.8 - 23.6	17.2 - 23.6

Table 1 shows that the optimum ratio (%) of wastewater mixing was 50:50 due to the good flocculation within shorter settling time. This means that 2 sources of effluent should be mixed together in the same volume. The amount of sludge was not significantly different and not much. It could be dried by sun and disposed as non-hazardous waste.

Table 2: Results of coagulation with different coagulant dose and adsorption with GAC.

Coagulant dose	Coagulation results Color of water pH		Adsorption results		
(% v/v)			Color of water	pН	
0.5	clear	5	clear	6.5	
1	slightly yellowish	3	clear	6	
1.5	yellowish	3	clear	5	
2	dark yellowish	2	N/A	N/A	
2.5	dark yellowish	2	N/A	N/A	

The optimum dose of ferric chloride solution was also determined in mixed effluent of A:B at 1:1. The results of different coagulant dose in Table 2 indicated that only 0.5% (v/v) of wasted ferric chloride solution was optimum for the coagulation of mixed effluent that contained varnish and glue. The flocculation was the best because the treated water was not yellowish as in Figure 3 (a) and the pH value was not too low in acidic range. After the water flowing through the GAC adsorption column, the pH was increased to be acceptable and the treated water was clear without color, as shown in Figure 3 (b).



Figure 3: (a) Color of treated water after coagulation with different coagulant dose (b) Color of effluent, treated water after coagulation/filtering, and after adsorption with GAC

Real-scale wastewater treatment system

The mixture of 50 L wastewater containing mixed varnish and glue was treated with optimum dosage of 250 mL ferric chloride solution in the real-scale of wastewater

treatment system. The schematic diagram of wastewater treatment system in this plant is shown in Figure 4 and the results of wastewater treatment is shown in Table 3.



Figure 4: The schematic diagram	of real-scale wastewater	treatment system in the
	plant.	

Table 3: Qualities of treated water from 3 samples of wastewater after coagulation and adsorption in real-scale treatment system.

Sample 1				
Parameter	Wastewater	After coagulation	After adsorption	Standard
		& filtration	with GAC	criterion
COD (mg/L)	23,850	5,464	33	<120
SS (mg/L)	568	18	4	<50
TDS (mg/L)	31,644	3,386	546	<3,000
pН	7.4	5	7.54	5.5-9.0
Sample 2				
Parameter	Wastewater	After coagulation	After adsorption	Standard
		& filtration	with GAC	criterion
COD (mg/L)	96,139	9,525	7	<120
SS (mg/L)	799	54	8	<50
TDS (mg/L)	36,644	3,370	652	<3,000
pН	8.2	5	6.83	5.5-9.0
Sample 3				
Parameter	Wastewater	After coagulation	After adsorption	Standard
		& filtration	with GAC	criterion
COD (mg/L)	56,719	7,163	29	<120
SS (mg/L)	951	90	8	<50
TDS (mg/L)	22,984	2,820	594	<3,000
pН	7.3	5	7.02	5.5-9.0

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The parameters of COD, SS, TDS values which indicated the contaminant in 3 samples of wastewater were removed by coagulation and adsorption, respectively, as shown in Table 3. The results showed that the treated water using 2 steps was acceptable with the parameter values under the standard criterion of industrial effluent. The removal efficiency of COD, SS and TDS in wastewater by coagulation and adsorption was analyzed as shown in Figure 5.



Figure 5: Removal efficiency of COD, SS and TDS in wastewater by coagulation and adsorption using wasted material in coating/lamination plant

Figure 5 indicated that the efficiency of COD, SS and TDS removal was very high by using the wasted ferric chloride solution as a coagulant. All parameters were further reduced to below the standard criterion by using the adsorption column of granular activated carbon. Therefore, the coagulation process using the acidic waste of the plant followed by the adsorption process using low cost activated carbon could be achieved with the removal efficiency at 97-99%. The sludge from coagulation process could be disposed by secure landfill and the spent GAC could be recycled or reused as the carbon-based fuel.

However, the volume of effluent A containing varnish from the coating machine washing was much more than that of effluent B containing glue from the lamination machine washing, as shown in Figure 1. If the effluent from 2 sources were mixed together at the ratio of 1:1, some volume of effluent A will be remained. The effluent A was then be tested for coagulation with wasted ferric chloride added with glue. It was found that 0.4% (v/v) of water-based glue could be used as co-flocculant to improve the flocculation efficiency of solid particles in effluent A. Therefore, the plant can use their wasted glue to reduce the cost of coagulation in treatment of the wastewater containing varnish coating.

Conclusions

The effluent from coating washing contained varnish and the effluent from lamination washing contained glue. Both effluents should be mixed together in the same volume before treatment by coagulation process using only 0.5% (v/v) of wasted ferric chloride solution which was optimum for the coagulation of effluent contained varnish and glue. The sludge could be separated from the water by filtering with

wasted mesh cloth. The yellowish color and the acidic pH of primary treated water could be removed by flowing through the GAC adsorption column. The removal efficiency of COD, SS and TDS was very high and the final treated water was acceptable with the parameter values under the standard criterion of Thai industrial effluent. The effluent containing only varnish could be treated by coagulation with wasted ferric chloride solution combined with 0.4% (v/v) of wasted water-based glue as co-flocculant to improve the flocculation efficiency.

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Unmanned Aerial Remote Sensing System (UARSS)-Derived Normalized Difference Vegetation Index (NDVI) to Soil Moisture Mapping

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Abstract

While satellite remote sensing systems have been widely applied to soil moisture monitoring, they are unsuitable for soil moisture monitoring of small areas, which merely cover several hectares, due to their low spatial or temporal resolutions. In order to address this problem, a multispectral sensor, Parrot Sequoia, carried on an unmanned aerial vehicle (UAV) is adopted to acquire the multispectral images with green (0.550 μ m), red (0.660 μ m), red-edge (0.735 μ m), and near-infrared (0.790 μ m) bands, as well as the geometric resolution of 0.2 m. Thus, thematic maps of Normalized Difference Vegetation Index (NDVI) can be derived by the differentiation of spectral responses between red and either red-edge or near-infrared. In this research, an agricultural field in Kinmen, Taiwan was selected as the study site, and several in situ sampling points were schemed for monthly data acquisition of soil moisture at two depths: 10 cm and 20 cm. Based on the in situ sampling data and the thematic maps of NDVI, an empirical model was established for soil moisture mapping. The preliminary results show that NDVI offers a good explanation for soil moisture at deep depth. The range of the estimated soil moistures are approximately between 10 and 20%.

Keywords: Unmanned Aerial Vehicle (UAV), Multispectral Sensor, Normalized Difference Vegetation Index (NDVI), Soil Moisture, Empirical Model

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1. Introduction

Soil moisture monitoring, which is usually implemented by the satellite-based remote sensing techniques (Wang, et al., 2007; Chen, et al., 2014; Mladenova, et al., 2014; Petropoulos, et al., 2015), has also been widely applied to hazard prevention (Hawke & McConchie, 2011; Laiolo, et al., 2016), agricultural management (Mallick, et al., 2009; Sakai, et al., 2016), and climate (Schnur, et al., 2010; Dente, et al., 2012; Fang, et al., 2016). Based on the satellite images, Wang, et al. (2007) and Chen, et al. (2014) calculated the normalized difference of vegetation indices (NDVIs) to establish the correlations between the NDVIs and soil moisture. Mladenova, et al. (2014) reviewed the passive microwave-based techniques and the soil moisture retrieval algorithms, where NDVI is involved. The spatial resolution of satellite images, such as the 250 m/pixel of Moderate Resolution Imaging Spectroradiometer (MODIS), is capable of NDVI analysis of country or continental scales, but is unsuitable for small areas merely covering several hectares. Furthermore, Wang, et al. (2007) and Petropoulos, et al. (2015) both indicated that while passive microwave radiometry and active microwave radar, such as synthetic aperture radar (SAR), have been widely applied to soil moisture mapping, the radar signal only penetrates soil surface to several centimeters so that only the soil moisture of the top few centimeters can be mapped. In this research, an unmanned aerial vehicle (UAV) due to its flexibility as well as reliability is considered as a good vehicle to carry a multispectral sensor for the acquisition of remote sensing data with high spatial resolution.

Currently, there are many applications of unmanned aerial remote sensing systems (UARSSs) to water quality monitoring (Su & Chou, 2015; Su, 2017; Guimarães, et al., 2017), forestry (Zarco-Tejada, et al., 2014; Chianucci, et al., 2016), agriculture (Bendig, et al., 2015; Gago, et al., 2015; Santesteban, et al., 2017; Romero-Trigueros, et al., 2017), and disaster management (Niethammer, et al., 2012). In particular, Bendig, et al. (2015) indicated that NDVI is useful for biomass monitoring of barley, and shows positive correlation related to water stress for agriculture (Gago, et al., 2015). Based on the above reviews, a linear regression model between calculated NDVI and observed soil moisture is established for soil moisture mapping. Additionally, a correlation between precipitation and soil moisture is also discussed in this paper.

2. Study Site and Soil Moisture Examination

Figure 1 shows the true color image of the study site, which covers approximately $100,000 \text{ m}^2$. In the study site, the land use includes agriculture, forest, water body, and path. On January 15, 2017, February 15, 2017, April 8, 2017, and May 4, 2017, at a total of twelve sampling points soil moisture was examined at two depths: 10 and 20 cm. The examination results are shown in Table 1.

Wang, et al. (2007) investigated the influence of soil moisture at different depths on NDVI and indicated that NDVI has a strong correlation with the water stress of vegetation. NDVI is also related to ground temperature varying with precipitation (Schnur, et al., 2010). At present, Table 1 cannot show a significant correlation between depth and soil moisture, but along with the accumulated sampling points, the correlation is still worth future discussion.



Figure 1: True color image of study site.

3. Unmanned Aerial Remote Sensing System (UARSS)

3.1 Unmanned Aerial Vehicle (UAV) and Flying Control System

A UAV with four rotor wings was chosen to carry the multispectral sensor (see Figure 2). The technical features of the UARSS include four 1.2 mega pixels sensors (near-infrared (NIR), red-edge (RE), red (R), and green (G)), as well as one 16 mega pixels RGB sensor (see Figure 3), ground resolution at 190 m of 0.2 cm/pixel, distance between two flying strips of approximately 65 m, image pitch of $256 \times 192 \text{ m}^2$, and end and side laps of 80% and 70%, respectively. The weather conditions, including visibility of 7000 m and cloud level of 3000 m, are also required.

Figure 4 shows an interface of the flying control system. Orientation, height, speed, and camera station can be instantaneously displayed on the interface, so global position system (GPS) and inertial measurement unit (IMU) are the two critical devices in the UARSS. Before implementing a flight task, the schemed flying strips must be input into the flying control system. During the flight task, the UAV can be precisely directed forward along the schemed flying strips, and the flying control system can automatically press the shutters at the correct camera stations (see Figure 5).

3.2 Multispectral Sensor and Image Data

For a unique scene, the multispectral sensor, shown as Figure 3, can offer four graylevel images in the channels, i.e. G (0.550 μ m), R (0.660 μ m), RE (0.735 μ m), and NIR (0.790 μ m), and a RGB image. Both of the RE and NIR channels belong to the invisible spectrums. RE is a narrow channel between R and NIR, so RE is effective in

discriminating vegetation against non-vegetation. The study site was imaged on December 8, 2016, February 17, 2017, April 7, 2017, and May 5, 2017. Figure 6 shows the multi-temporal false color images of the study site. Because the multispectral sensor has the RE and NIR channels, two kinds of false color images can be obtained.

Table 1: Soil moisture examination of sampling <i>in situ</i> .					
	Coordinate system:				Soil moisture
Sampling date	GCS_TWD_1997		Depth (cm)		
	ID	N	Е		(70)
	1	2707927	100001	10	11.86
	1	2101921	170071	20	13.57
January 15, 2017	2	2707927	100080	10	21.73
January 15, 2017	2	2101921	170007	20	18.17
	3	2707906	100111	10	5.36
	3	2707900	190111	20	5.30
	1	2707946	100003	10	13.17
February 15 2017	4	2707940	190095	20	14.92
1 coluary 15, 2017	5	2707004	100112	10	3.45
	5	2707904	190113	20	3.35
	6	2708014	100084	10	6.48
	0	2708014	190084	20	7.28
April 8 2017	7	2707067	180006	10	18.89
April 8, 2017	/	2707907	189990	20	17.91
	Q	2707068	100064	10	13.25
	0	2707908	190004	20	32.12
	0	2707047	100001	10	17.19
	9	2/0/94/	190091	20	12.51
	10	2707052	100047	10	12.91
Max 4 2017	10	2101932	190047	20	11.81
May 4, 2017	11	2707000	100046	10	11.97
	11	2707999	190040	20	14.56
	10	2702011	100074	10	11.67
	12	2708011	1900/4	20	14.98

4. Methodology

4.1 Calculation of NDVI

In each monitoring task, the study site will obtain two false color images (see Figure 6). Thus, the following two NDVIs are presented in this paper:

NDVI_2 =
$$(RE - R) / (RE + R).$$
 (2)

NDVI being equal to 1 means that the R channel has no spectral response; on the contrary, if either the NIR or RE channel has no spectral response, NDVI is equal to -1. Thus, NDVI ranges between -1 (not good vegetation) and 1 (good vegetation).



Figure 6: False color images of the study site; (a) through (d) Images consisting of channel 1: NIR, channel 2: R, and channel 3: G; (e) through (h) Images consisting of channel 1: RE, channel 2: R, and channel 3: G.

4.2 Empirical model

Vegetation status usually is related to soil moisture of the root zone (Alvarez-Garreton, et al., 2015; Laiolo, et al., 2016); precipitation-runoff and land uses also influence soil the moisture of the root-zone (Renzullo, et al., 2014). In this research, a

linear regression model between NDVI and soil moisture is introduced. Referring to the linear model of Wang, et al. (2007), the empirical model for soil moisture mapping is represented as:

$$\mathbf{Y} = \boldsymbol{a} \cdot \mathbf{X} + \boldsymbol{b},\tag{3}$$

$$a = (\mathbf{X}^{*}\mathbf{X})^{-1}\mathbf{X}^{*}\mathbf{Y},$$
(4)

$$\acute{\mathbf{Y}} = \mathbf{X} \cdot a, \tag{5}$$

where **X**, **Y**, *a*, and *b* signify NDVI, soil moisture, constant, and random error, respectively. Estimated soil moisture ($\hat{\mathbf{Y}}$) can be explained by NDVI (**X**) according to a square of Pearson correlation coefficient.

5. Preliminary Results and Discussion

5.1 NDVI calculation

Based on the false color images in Figure 6, the NDVIs of the study site are calculated and shown as Figure 7. The statistics of the NDVIs in Figure 7 are shown as the histograms in Figure 8. Compared with the statistical histograms of NDVI_1 and NDVI_2, the statistical histograms have similar patterns and the approximate NDVI ranges. The NDVI ranges in late 2016 and early 2017 both were $-0.4 \sim 0.4$. Based on NDVI_1, the standard deviation for the statistical histograms in the period of December 2016 through April 2017 was slightly increased from 0.026 to 0.039 but reduced to 0.027 in May 2017. Based on NDVI_2, however, there is a steady standard deviation of approximately 0.027 for the statistical histograms in the period of December 2016 through May 2017. The above result demonstrates that the NIR and RE channels have similar performance in NDVI calculation. Moreover, NDVI_1 has the better capacity than NDVI_2 for detecting slight difference of vegetation biomass.

Due to the growth of the wheat, the gray levels of the agricultural field in early 2017 are obviously brighter than those in late 2016 (see Figure 7). However, the forest had darker gray levels in early 2017 than in late 2016. Compared with Figures 8(a) and (b), there is the more number of pixels with the NDVIs between 0.2 and 0.4 in early 2017 than in late 2016. This result demonstrates that the growth of the wheat leaded to an increase of the number of pixels with the above positive NDVIs. On the contrary, a decrease of the forest biomass resulted in the increase of the number of pixels with the negative NDVIs between -0.2 and -0.4. After April 2017, the wheat was reaped so that the agricultural field displayed bare soil. Figures 8(b) through (d) are seen that the number of pixels with the positive NDVIs after April 2017 is significantly less than in February 2017.

Figure 9 shows the monthly precipitation from November 2016 to May 2017; it can be conjectured that the darker gray levels of the forest in early 2017 are related to the precipitation. The monthly precipitation suddenly dropped from 123.1mm in November 2016 to 28mm in December 2016. Whereas the precipitation in February 2017 is greatly increased, the growth of the forest is healthier after than before February 2017. Thus, the soil moisture of the forest also should be increased after February 2017. Theoretically an increased precipitation will induce an increase of

vegetation biomass to raise NDVIs, but the vegetation biomass in the agricultural field is additionally controlled by farming that hampers this study to establish a robust correlation between NDVI and soil moisture.



Figure 7: NDVI calculation results; (a) through (d) NDVI_1; (e) through (h) NDVI_2.



Figure 8: Statistical histograms corresponding to Figure 7.





Date of UARSS imaging	ID of sampling in situ	NDVI_1	NDVI_2
	1	-0.1173	-0.0642
December 8, 2016	2	-0.1256	-0.0601
	3	-0.0017	0.0059
February 17, 2017	4	-0.3132	-0.2414
February 17, 2017	5	-0.0373	-0.0049
	6	-0.0513	-0.0289
April 7, 2017	7	-0.1099	-0.0940
1	8	0.0794	0.0749
	9	0.1730	0.1610
May 5, 2017	10	0.0203	0.0298
	11	0.0306	0.0364
	12	-0.1232	-0.1072

Table 2: NDVI calculation results of <i>in situ</i> sampling points.	Table 2: NDVI	calculation	results of in	situ samp	ling points.
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5.2 Empirical Model Establishment

Table 2 lists the NDVI calculation results for the *in situ* sampling points. Based on Tables 1 and 2, the empirical models' correlations between NDVI and soil moisture are established, as shown in Figure 10. So far there is not a significant correlation between the NDVIs and the soil moisture. Nevertheless, Figures 10(a) and (c) show the negative correlation between NDVI and soil moisture that is contrary to the expected positive correlation. It is evident that some of the sampling points, i.e. the IDs of 1 through 3, have a temporal gap of approximately one month between the UARSS imaging and the measurement in situ. Theoretically, a higher NDVI should reflect higher soil moisture strengthening vegetation biomass, but the correlation between NDVI and soil moisture is negative; this may result from the temporal gap or the positioning precision limit of 5 m of our handheld GPS. Considering the positioning precision limit, an NDVI in Table 2 is derived by averaging the NDVIs in an area of 5×5 m². In the averaged NDVI, the NDVIs of land uses of non-vegetation, such as bare soil, are also probably involved, so in Table 2 some of the averaged NDVIs are negative. In spite of that, currently the sampling size of soil moisture examination is too small to identify the precise correlation between NDVI and soil moisture. Long-term monitoring of soil moisture is still needed in this research.

Due to the negative correlations in Figures 10(a) and (c), the observed soil moistures at the shallow depth cannot be reasonably explained by the calculated NDVIs. The obtained empirical models in Figures 10(a) and (c) are abandoned in the next stage of soil moisture mapping. Between Figures 10(b) and (d), NDVI_2 compared to NDVI_1 has the better explanation for the observed soil moistures at the deep depth. In other words, the RE channel, where the channel width is about 0.01 μ m, is more useful than the NIR channel, where the channel width is about 0.03~0.04 μ m, in the establishment of the empirical model. Also, the RE channel should be more sensitive than the NIR one in soil moisture detection.

5.3 Soil Moisture Mapping

According to the linear models shown as Figures 10(b) and (d), the mapping results for the soil moistures at the depth of 20 cm are shown as Figures 11 and 12.



Figure 10: Empirical models; (a) and (b) show the models between NDVI_1 and soil moisture at the depths of 10 and 20 centimeters, respectively; (c) and (d) show the models between NDVI_2 and soil moisture at the depths of 10 and 20 centimeters, respectively.



Figure 11: Using the empirical model of $\mathbf{Y} = 3.1281\mathbf{X} + 14.024$ for soil moisture mapping at the depth of 20 cm.



Figure 12: Using the empirical model of $\mathbf{Y} = 19.716\mathbf{X} + 14.432$ for soil moisture mapping at the depth of 20 cm.

The soil moisture mapping in Figure 11 is produced by the empirical model of $\mathbf{Y} = 3.1281\mathbf{X} + 14.024$. In December 2016, the estimated soil moistures in the agricultural field are approximately between 13 and 14%. Along with the growth of the wheat, the soil moistures mostly between 15 and 16% are estimated for the agricultural field in February 2017. In April or May 2017, the estimated soil moistures in the agricultural field drop back between 13 and 14%. However, the drop of the estimated soil moistures results from the radiometric reflectance decrease of the NIR channel due to the reaped wheat. The estimation precision for the agricultural field still needs to be surveyed in the future. As for the forest, the variation of the estimated soil moistures is just contrary to that of the agricultural field. In December 2016, the estimated soil moistures in the forest are approximately between 14 and 15%. Along with the decrease of the precipitation, the estimated soil moistures are also slightly decreased in February 2017. In April or May 2017, the estimated soil moistures in the forest are approximately between 14 and 15%.

The variation tendency of the estimated soil moistures in Figure 12 is similar to that in Figure 11. Nevertheless, the soil moisture mapping has the better contrast in Figure 12 than in Figure 11 because the RE channel should be more sensitive than the NIR one in soil moisture detection. In conclusion the above results of soil moisture mapping

demonstrate that climate factor, such as precipitation, could influence soil moisture. However, human activity, such as farming, would hamper soil moisture estimation.

6. Conclusion

This paper presents a UARSS technique and discusses the influences of precipitation, soil depth, and invisible channels on soil moisture mapping. The UARSS demonstrated its potential for establishing the correlation between precipitation and soil moisture. The current size of sampling *in situ*, and the remote sensing data are still insufficient, but some preliminary results have been obtained in this paper. Firstly, NDVI is calculated based on the spectral channels of R, RE, and NIR of Parrot Sequoia, and demonstrated its effectiveness in soil moisture mapping. Moreover, RE compared with NIR can establish a better empirical model between NDVI and soil moisture. Secondly, precipitation and human activity both would impact soil moisture, and NDVI offers a good explanation for soil moisture at deep depth. At present, the obtained correlation between NDVI and soil moisture at shallow depth is negative, which is contrary to the hypothesis of positive correlation. In the future, the correlation between NDVI and soil moisture still needs to be correctly identified, and an estimation accuracy of soil moisture mapping also needs to be surveyed.

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GPS Module Programming of Sun Position Algorithm for 2-Axis Sun Tracking System

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Abstract

The overall objective of this study is to design and develop a program for controlling A Dual axis sun tracking system with astronomical equation program on Arduino via GPS module. This paper discusses about mechanical structure, concept of program and algorithm base on the astronomical equation in Thailand. The concept of this tracking system is to collect GPS location and real-time data of date and time to calculate Azimuth and Elevation angle without another sensors, which is usually have problem of sun tracking. The dual axis sun tracking controller system develops by using an 8 bits Arduino MEGA via GPS module. This paper also compares the efficiency of the dual axis sun tracking system and a non-tracking system under the same location and environment.

Keywords: Dual Solar Tracking System, Arduino, GPS Module

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Introduction

In Thailand, Alternative Energy Development Plan (AEDP : 2015-2036) have Solar is the most proportion number about 6,000 MW shown in Figure 1. Now Solar Plant in Thailand about 1,420 MW, almost of them is fixed type can be percent about 98%. In Solar Roof top (fixed type) is about 20%, Solar Power Plant (fixed type) is about 78% and the tracking System just have in solar power plant only. It's about 2 %. For capacity factor of solar roof top (fixed type), there is 20 units in Metropolitan Electricity Authority Area, that is about 12% shown in Figure 2.



Figure 1 : PDP2015 Proportion



Figure 2 : Capacity Factor Solar Rooftop
The problem of loss factors of solar plant fixed type consist of first, a season problem with the direction of motion of the sun, the energy value is not maximum efficiency. And second, sun path problems with path moving of the sun in each day, the sun always moving, not stop shown in Figure 3. So increasing efficiency of solar plant is moving PV module, which always track the sun.



Figure 3 : Problem of the statement

The solar tracking systems have 3 types, which include of one axis Tracking, one axis tracking with tiled angle and dual axis tracking system shown in Table 1.

Table 1 : Type of Solar Tracking

Solar Tracking Type	% efficiency more than fixed type
One Axis	13 %
One Axis with tiled angle	17%
Dual Axis	20%

Idea and Concept

For the idea for dual tracking program can consist of 3 main parts shown in

Figure 1. First Data Time and Location (Latitude and Longitude), in red block, that can get the data from GPS Module We choose the EM506 from Sparkfun. Second Astronomical Parameter it's consist of the basic parameter, in blue block, that can calculate by Microcontroller we choose the Arduino MEGA 2560 as, develop by C# programming. The last is the sun angle parameter, in orange block, Angle after calculated from arduino, that command the motor drive for Sun tracking.



Figure 4 : Idea and Concept

For structure of dual axis tracking module can shown in Figure 5, that consist of 5 point. Position A is rotation point of Elevation / Zenith angle. Position B is rotation point of Azimuth angle. Path C is rotated direction of Elevation / Zenith angle. Path D is rotated direction of Azimuth angle. Position E is dish for install Pyranometer or PV Module.



Figure 5 : structure of dual axis tracking module

For collect of data and analysis, use comparing result (Azimuth and Elevation Angle) during a year between general calculation with result from calculation of Arduino and General calculation with actual tracking feedback from potentiometer following Figure 6.



Figure 6 : Data Collection and Analysis

Result

First, the result data collection with simulation during in year 2017 for checking error of the program and system, which have error about 5%. In month May have error highest in year, that is about 40-50 %



Figure 7 : Error of the program and system

Second, the compare solar radiation between dual solar tacking with fixed tiled south 15 degree. The Dual solar tracking system can increase efficiency more than fixed type about 15% shown in Figure 8.





Conclusion

In conclusion, it is clear that the dual solar tracking system can receive radiation from the sun more than the fixed type south 15 degree is about 15%. And the program has the error average 5 % for simulation in year 2017. But this module and system is a model of pilot for studying the concept of program and create the simple and basic module, which cannot protect water and dust.

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The Coupling Effect Analysis Between Economic Growth, Industrial Structure and Environmental Pollution in China

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Abstract

It is important to explore the coupling relationship between economic growth, industrial structure and environmental pollution. In numerous analysis frameworks which used for studying economic growth, industrial structure and environmental pollution, many scholars verified whether the situation of local area in accordance with the Kuznets curve, the obtained results were always diverse. Dividing China into 3 regions of eastern, central and western, the paper study the relationship between economic growth, industrial structure and environmental pollution by using coupling coordination degree model to analysis 28 provinces and cities' panel data in 2000-2016. The study found that the economic and environment development in most prefectural units are still at a lower level of coupling and coordination. There are significant disparities in coupling and coordinating degree between eastern coastal areas and western inner areas. And economic growth has a significantly positive impetus to environmental pollution while the improvement of economic growth comprehensive level leads to the deterioration of environmental conditions; China's current industrial structure is in good condition and it has crossed the inflection point of the inverted U-shaped curve into the stage industrial structure improve environment pollution; economic growth has a bigger direct positive effect on environmental pollution and it also indirectly affects environmental pollution by influencing industrial structure, technological progress and population quality.

Keywords: Economic growth, environmental pollution, industrial structure, coupling and coordinating degree

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1 Introduction

Since the reform and opening up, the economic growth process in China is developing rapidly. China's economic growth rate back to the world's first has reached 6.7% by 2016, above the level of developing countries into the middle. The economic growth promotes China's economic development and improves people's living standards, but also brings the increasingly serious environmental problems. Population and industry continuously move to towns increasing environmental pollution, resulting in a significant "urban disease" problem. How to improve environmental pollution and promote ecological environment in the development of urbanization becomes the focus of the study. Industrial structure upgrading as an important means of resolving the conflicts between the two and coordinating the development of the two attracts attention. At present, the academic circle has obtained many achievements in the research of economic growth, industrial structure and environmental pollution, but they often separated the three. In this context, it has important theoretical and practical implication to explore what are the laws between the three; whether the current level of China's economic growth and industrial structure are suited to the level of ecological environment and how economic growth and industrial structure influence environmental pollution.

According to research we know that since GROSSMAN proposed the Kuznets curve (Kuznets)--the famous inverted "U" curve--to explain the relationship between economic development and environmental pollution, economic growth, industrial structure and environmental pollution problem has been the attention of scholars. In numerous analysis frameworks which used for studying economic growth, industrial structure and environmental pollution, many scholars verified whether the situation of local area in accordance with the Kuznets curve, the obtained results were always diverse.

Over the past few decades, numerous scholars have researched the mutual relationship between economic activity and eco-environment. In the 1970s, some economists explored the conditions, processes, and elements of the coordinated growth relationship between the economy and environment using economic growth theory. For instance, Yan Xinhua(2006) indicated that a few economically developed areas have Kuznets curve characteristics in terms of time. Liu et al. (2005) built a coupling model between Chinese regional urbanization and eco-environment with the grey relative degree model and analyzed the spatial characteristics of the relationship between urbanization and eco-environment at the provincial level. At present, many domestic and foreign scholars believe that there is a close relation between industrial structure change and economic growth, since domestic scholars also used the empirical analysis of China's reform and opening up the adjustment of industrial structure promotion effect to economy growth. Bao Qun (2014)using the panel data of 6 indicators for 1996-2000 waste covering over 30 provinces, then through the establishment of pollution protection equation and output equation analyses the relationship between economic development and environmental pollution. It reveals the deep-seated reasons for the continued deterioration of the ecological environment in China.

2 Methods

Coupling is a type of relationship in which one system or subsystem and another, or one subsystem and the elements in another subsystem mutually influence and affect each other. The interactive coupling relation of economy and environment is the sum of their interaction, mutual influence and nonlinear relation. The assessment of degree of coupling can be performed in four steps:

2.1 Constructing assessment indicators of economic and environmental subsystems

According to previous research methods, We chose 28 provinces in China as assessment objects, select the study sample interval is from 2000 to 2016. One reason for this choice is that these 28 provinces are somewhat independent geographically and spatially. Another reason is that they are independent economic entities. The data are come from the economic networks statistics database, Chinese Statistical Yearbook, China land resources Yearbook and the local statistical yearbook (Table 1).

System	Function	Indicator		
Economic Comprehensive development index	Regional economic power	GDP per capita Average gross value of industrial output		
		Financial revenue per capita		
	Regional development potential	Gross fixed assets investment		
		Financial expenditure		
	Regional development vigor	Gross volume of passenger transport		
		Gross volume of cargo transport		
		Gross retail sales of social consumer goods		
Environmental	Atmospheric environment variables	SO2 emission		
comprehensive		Inhalable particle concentration		
development index		Waste gas treatment rate		
	Water environment variables	COD emission		
		Industrial wastewater treatment rate		
		Wastewater discharge		
	Ecological construction	Soil erosion rate		
		Forest coverage		
		Urban green coverage rate		
	Economic environment related variable	The proportion of environmental investment in GNP		
Table 1: Indicators for evaluating the regional economic and environmental				

subsystems in China

source: Chinese Statistical Yearbook.

2.2 Calculating the efficiency function

The regional economy–environment coupling system is composed of an economy subsystem and an environment subsystem. Each subsystem is constituted by various indicators. Suppose there are "*n*" indicators in subsystem *i* named $x_1, x_2, ..., x_n$. The efficacy coefficient d_{ij} of the indicator in the regional economy–environment coupling system would be expressed as:

 $d_{ij} = (x_{ij} - x_{ij} \min) / (x_{ij} \max - x_{ij} \min) \text{ positive indicators}$ $d_{ij} = (x_{ij} \max - x_{ij}) / (x_{ij} \max - x_{ij} \min) \text{ negative indicators}$ (1)
where d_{ij} is the efficacy coefficient of indicator j in subsystem $i_{i} x_{ij}$ max is the maximum score of indicator j in subsystem i; xij min is the minimum score of indicator j in subsystem i; and $0 \le d_{ij} \le 1$. d_{ij} shows the degree of satisfaction of the goal. $d_{ij} = 0$ means the lowest degree of satisfaction.

2.3 Comprehensive assessment of subsystem efficacy

The comprehensive efficacy of the subsystem is the integration of the contribution of all indicators to its subsystem, which can be achieved using the formula:

$$u_i = \sum w_{ij} d_{ij}$$
(2)

 $w_{ij} \ge 0, \Sigma w_{ij} = 1, j = 1, 2, ..., n$

where u_i is the comprehensive efficacy of subsystem *i* and wij is the weight of indicator *j* in subsystem *i*.

2.4 Assessment of the degree of coupling and coordination of the regional economic and environmental systems

With the concept of capacity coupling and the capacity coupling coefficient model in physics, we obtain a degree of coupling model for the mutual function of multiple : .

$$C = \{(u_1 \times u_2 \times \dots \times u_n) / [\Pi(u_i + u_j)/n]\}^{n(1/n)}$$
(3)

According to formula (3), we know that $0 \le C \le 1$. The degree of coupling score is between 0 and 1. When C = 1, the degree of coupling is the largest, and the system has benign resonance and is working into a new orderly structure. When C = 0, the degree of coupling is the smallest, and one subsystem and another (or one element and another) will be uncorrelated, and the coupling system will tend to be disordered.

Coordination is the feature in which all of the elements are in harmony with each other in the process of system evolution. The model of degree of coordination can reflect the level of harmony in an economy and environment coupling relationship, and it can be calculated as follows:

$$T = (au_1 \times bu_2)^{(1/2)}$$
(4)
$$D = (C \times T)^{(1/2)}$$
(5)

where D is the degree of coordination, C is the degree of coupling, and T is the comprehensive coordinating index of economy and environment, which reflects the effect or contribution of integrated synergy of economic development and the environment. a and b are weights to be determined. Because the economy is as important as the environment, a=b=0.5.

According to the distribution of u_i , the value of the comprehensive efficacy of the subsystem, the value of the degree of coordination D is between 0 and 1. The higher the comprehensive efficacies that the economic and environmental subsystems contribute to the whole system, the higher the value of the degree of coupling and coordination will be. Additionally, the better the economic and environmental systems is, the more harmonious their relationship.

3 Conclusions and discussion

Through modeling and literature research, we can draw the following five conclusions:

First, there is an interactive coupling relationship between regional economy and environment. As two subsystems, the interaction between them exist four stages. They're low water coupling, antagonism, running-in and high level coupling. They restrict each other. Coordinating the development relationship of the two subsystems is the basis of the benign development of the large scale economic environment system.

The second, economic growth has a significantly positive impetus to environmental pollution while the improvement of economic growth comprehensive level leads to the deterioration of environmental conditions; China's current industrial structure is in good condition and it has crossed the inflection point of the inverted U-shaped curve into the stage industrial structure improve environment pollution; economic growth has a bigger direct positive effect on environmental pollution and it also indirectly affects environmental pollution by influencing industrial structure, technological progress and population quality. The coefficient of Industrial structure is the largest among the indirect path, which means industrial structure is the most effective way to improve environment pollution.

Third, the coupling degree of economic development and eco-environment is the synergy between order parameters in the interaction process of regional economy and ecological environment. It reflects the trend of the system from disorder to order. The development of the economic system will lead to the deterioration of the ecological environment. After the economic grew to a certain extent, it will also promote the environmental protection. The coupling-coupling model in this development process consists of the efficacy function, the coupling degree function and the coupling degree index system. Among them, the establishment of the upper and lower bounds of order parameter and the establishment of the coupling index system are the key to the correct application of the model.

Fourth, with the structure analysis of the industrial sectors in the four stages, it can be seen that the polluting industrial sectors accounted for the highest proportion in the running-in stage and antagonism stage. Furthermore, the dominant industrial sectors in the antagonism stage were mainly mining and metallurgy industries with low value-added and high-pollution discharge, and should be the most important type of area for environment monitoring and regulation. China's current industrial structure is in good condition and it has crossed the inflection point of the inverted U-shaped curve into the stage industrial structure improve environment pollution; economic growth has a bigger direct positive effect on environmental pollution and it also indirectly affects environmental pollution by influencing industrial structure, technological progress and population quality. The coefficient of Industrial structure is the largest among the indirect path, which means industrial structure is the most effective way to improve environment pollution.

Final, dividing China into 3 regions of eastern, central and western, the paper study the relationship between economic growth, industrial structure and environmental pollution by using coupling coordination degree model to analysis 28 provinces and cities' panel data in 2000—2016. The study found that the economic and environment development in most prefectural units are still at a lower level of coupling and coordination. There are significant disparities in coupling and coordinating degree between eastern coastal areas and western inner areas. And economic growth has a significantly positive impetus to environmental pollution while the improvement of economic growth comprehensive level leads to the deterioration of environmental conditions. In addition empirical results suggest that the effect of economic growth to environmental pollution copes with the Environmental Kuznets Curve from the perspective of the whole nation, laying on the right downward part of the inverted-U curve. From regional perspective, there also exists inverted-U shaped curve in the eastern and middle regions while in the western region the relationship appears to be N shaped. Meanwhile, the influence of other factors displays distinct characteristics.

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The Study of Design Elements and User's Behavior in Public Space: A Case Study of Pattaya Beach Road Public Space

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Abstract

This research aimed to investigate the user's behavior of the public open space, a case study of Pattaya beachfront public space, Chonburi province, the second most visited city in Thailand, after Bangkok. By studying the characteristic of landscape design elements, activities and the surrounding context to analyze the relationship of the various factors that affecting the use of the area, to find out the design guidelines to improve the physical design of Pattaya beachfront public space which based on the behavior and needs of users. The Post-Occupancy Evaluation methods were used to collect and analyze data by observation, interview and review the literature. The observations are divided into two parts: the overall physical and usage character of the whole area, the second part is the user's behavior in the space which was classified into 3 types, plazas, walkways and memorial place. Then analyze the current usage conditions of each area, positive&negative aspects and compare with the public open space design guidelines. The results showed that during the weekend at 04.00pm-06.00pm is the most active time of Pattava beachfront public space. The user's both Thai and foreigner, intensively use in many kinds of recreational activity. The main application is the walkway between the north and south of Pattaya beach. And also be the space for recreations. The factors that promote the usage are the activities of the surroundings context Pattaya Bay and physical include: landscape design elements accessibility. the beauteous scenery. daylight&shading, appropriate dimension of space, security and the natural atmosphere.

Keywords: Public Open Space, Post-Occupancy Evaluation, Landscape Design, Pattaya Beach

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1. Introduction

The public space is the social and recreational areas, a place to relax the body and help in healing the mind from the problems in everyday life. And enhance the life's quality of people at all levels. Which means the public space is definitely an area that needs to be sustainable in the urban community. The general public space may be a green shady area which are designed to provide the space for various actions. Especially the public space which is located in the high- density community area or the tourist attraction, the public space must respond the various type of use and people, who's come outside to spend their time in many purposes.

Pattaya City is one of the most attractive city of Thailand, which the urbanization process is suddenly growing too fast in the several decades. From the data of Designated Areas for Sustainable Tourism Administration found that in each year both Thai and foreigner had visited the city an annual average of about 6 million people and could bring income to the national average of 2 hundred million dollars, representing 10 percent of the whole tourism income of Thailand. By the number of visitors has increased every year, compared with the existing infrastructure. Make the current are environmental problems, In particular, a city is now experiencing a shortage of public spaces for recreation, which response to the users and amount of tourist and people of Pattaya.



Figure 1: Pattaya City, Chonburi province, Thailand (Image from Internet)

With the appearances of the coastal tourist city, makes the Beach area of Pattaya Bay to be the most important area of the city, the natural attraction and the location of the city's economic district include the area around Pattaya beach road from the north beach to the south beach. Therefore, this study aims to find out the way to develop the quality of the public space which been limited in Pattaya City. By studying the Pattaya Beach Road Public Space. The results from this study can be used as a design guideline to improve the physical characteristics of the public space, in accordance with the user's behavior and are consistent with the characteristic context Pattaya City. And also be related to the policy of the urgency of the development plan for the city of Pattaya.

The Aim, Objectives, and Questions of the study

The aim of the study

To find the design guidelines for the design and development of the public space, in accordance with the user's behavior and usage of the Pattaya beach road public space.

The objectives

1. To study the user's behavior of the study area, Pattaya beach road public space.

2. To study the relationship between the physical characteristics of the area and the behavior of users in doing activities in Pattaya beach road public space

3. To propose the design guidelines for the public space that suits the user's behavior, and in accordance with the design guidelines for the good public space. To be a tool for improving the Pattaya beach road public space and another related area.

The questions of the research

1. The physical characteristics of the Pattaya beach road public space are consistent with the usage behavior of users. And responds to the need to use the area in the proper way or not?

2. The physical characteristics of Pattaya beach road public space are in accordance with the characteristics of the good public space design?

2. Related Literature

Street Plaza - Linear Open Space

Linear open space is one type of the downtown Plaza, the public space which located nearby the downtown or the attraction place of the city. And the location might be located along the side of building, the road or the waterfront. The shape and size of the space generally being long and narrow, and the function is similar to the path or walkway. The important elements that make the linear open space being different from the other type of downtown plaza are the expanded space or elements that can support the various use, moreover being the only walkway. Such as the green shade, seating and the waiting area or the place for looking the people's activity and the happening of the city (Cooper Marcus & Francis, 1990) the main design recommendations for the linear open space can be shortly described as 4 points: Location, The Size, The Visual Complexity and The Activity of the space.

12 Quality Criteria for Designing/Detailing the Good Public Space

In the 1960s, Jan Gehl start to study what people actually do in the public spaces and in his book "Life Between Buildings", which was published in English in 1987, he describes the logic of how people use the physical environment and led to the new research which explain about the 12 quality criteria for the design of good public space and this topic had been published in a new book "New City Life" in 2006

The Quality Criteria are divided into three groups: Protection, Comfort, and Enjoyment with the details of aspects are as the following diagram:



1. Protection

- · Protection Against Traffic and Accidents
- Protection Against Crime and Violence
- Protection Against Unpleasant Sensory Experience



Aesthetics Quality/Positive Sensory Experiance

Figure 2: The quality criteria for designing the good public space

3. The Research Methodology

This study is the Qualitative Research which aims to investigate and identified the physical design characteristics and the current usage of Pattaya beach road public space. To know the current quality of the public space in responding and supporting the needs of users. The details of the process are as follows.

3.1 Scope of the study area

Pattaya beach road public space is located in the area of Pattaya Bay nearby the Pattaya Sai 1 Road (Pattaya Beach Road), Nongprue, Banglamung, Chonburi province, Thailand.

The estimated distance of the Pattaya beach road public space is about 2.7 kilometers (From the north beach to the south beach)



Figure 3: Scope of the study area, Pattaya Beach Road Public Space (source by the author)

3.2 The Field Data Collecting.

The field data collecting method that was used in this research was developed from the Post-Occupancy Evaluation (POE) methods. POE is defined as a process for the evaluation of built environments from user's perspectives and it is used to find out the way to improve the quality of the provided space, to raise the effectiveness of the place and productivity of users. In this research, POE was used to investigate in 3 aspects of spatial performances: 1. Physical Elements 2. Functions and 3. User's Behavior. The processes of POE to evaluate the study area are:

1. Pilot Observation: A preliminary surveying of the area to know the overview characters of the physical settings and usage's behavior from 08.00-18.00 of the day throughout the week, to specify the date and time of the public space which is used the most heavily. (The most heavily used time is the time that might have the problems and conflicts of using which proper to study and identified the issues or problems of the place)

2. Observation of the place: An indicative surveying is used to identify the physical design elements and the happenings of user's activity in the sub-areas which were classified from the pilot observation. By recording in the behavior map and table of usage quantity.

3. Interviewing the users that are involved in the study area. To know the purposes, intentions, behavior in each using period and attitudes in using Pattaya beach road public space.

3.3 Period of the Observation.

The date and time of the field data observation were chosen by the tourism's peak period (High-season) of Pattaya city, which starts from November to April of each year.

3.4 The Data Interpreting and Analyzing.

1. Analyze the pilot observation's data that include the overall physical characteristics and current usage of Pattaya beach road public space to conclude the use of the study area throughout the week (Monday-Sunday) and specified the date and time of the most heavily used of the area. And also classified the characters of the public space into several sub-areas, to study the use of the area thoroughly.

2. From the subarea's observation, analyzing the data in terms of user's behavior and circulation by using the behavior map and table of usage quantity. Conclude the usage quantity in each area to identify which the activity and the area are the most and least usage, the analysis also is combined with the current physical design elements.

3. Analyze the physical factors that promote the uses of Pattaya beach road public space by considering the relationship of the elements, including the characteristics of the surrounding context of Pattaya Bay and the physical design elements of the study area.

4. Analyze the physical design of the Pattaya beach road public space, consistent and inconsistent with the design guidelines or criteria of good public space which based from the reviewing the literature.

5. The conclusion of the analysis phase will be led to answer the research question and propose the design recommendations to improve the quality of Pattaya beach road public space.

4. Pattaya Beach Road Public Space

The physical character of Pattaya beach road public space is the linear open space which located along the Pattaya Sai 1 Road (Pattaya beach road). The road is one of the minor streets with concrete one-way driving and has 2 traffic lanes, the width of the traffic territorial include vehicles lane and sidewalk is 12 meters. The traffic density of the road is between medium and low and the velocity of the vehicles is quite low because of the downtown surrounding context and also people's activity on the beachfront area.



Figure 4: The Pattaya Sai 1 Road (Pattaya Beach Road). (Revised from Google Earth)

From the pilot observation, Pattaya beach road public space can be classified the physical characteristics into 3 types as follows:

1. Multi-Purpose Space/Plazas: the area which was extended from the other part of the walkway to be a large space with the internal area that can be utilized a variety of activities and also can support the installation or exhibition in the special occasion.

2. Walkways/Promenades: the area with the long and narrow space which serve for people to walk along the public space and connect each sub-areas. And also be the buffer space between the beach area and the vehicle lanes (Pattaya beach road)

3. Memorial Place: the area or place which is important and valuable in the history of Pattaya city and also related to the belief of the native people.

By the classification of the overall physical design and activities on the Pattaya beach road public space, the case study area can be separated into 7 sub-areas to be easy and convenient in observation the happenings of the place. The sub-areas are as follow:

Area No.1 Plaza at the north Pattaya
Area No.2 Plaza at the King Taksin the great's shrine
Area No.3 Promenade between the north and the middle of Pattaya
Area No.4 Plaza at the middle Pattaya
Area No.5 Plaza opposite the Central Festival Pattaya Beach (Department store)
Area No.6 Royal Varuna yacht club memorial
Area No.7 Promenade between the middle and the south of Pattaya



Figure 5: The overall characteristics of physical design and activities on Pattaya beach road public space. And the location of the sub-areas study (drawn by the author)

5. The Uses of Pattaya Beach Road Public Space

5.1 Conclusion of the overall observation in the behavior of the whole study area.

Types of User's Activity, The Users and The Most Heavily Using Time of Pattaya Beach Road Public Space

From the pilot observation of the overall using in the study area, the surveying shows that the activity which was taken place in the study area can be classified into 2 types including:

Passive Activity: (1) Standing/Sight Seeing, (2) Sitting, (3) Picnic/Sitting on ground
 Active Activity: (4) Walking along, (5) Jogging

The users which were found in the study area are both Thai and foreigner tourist. The most of the tourist are the foreigner from overseas and mostly stay in the hotels, resort and other accommodations from 5-7 days.

If classify users according to the gender and age, found that the number of male users is more than female. Most of the male users usually come together as a group of friend, but female users usually come with the families. The users of Pattaya beach road public space are mostly adults and the young people are found in less amount to none.

The date and time which are the most-heavily using time of Pattaya beach road public space are during the evening between 04.00pm-06.00pm at the weekend (Saturday-Sunday). Because in this period, the weather is quietly cool down from the heat of the sun and people also can archive the beautiful scenery of the sunset view. Moreover, the beautiful view and the proper climate, the atmosphere of the nightlife district also becomes more active than daytime which brings people to come out and enjoy the happenings events of Pattaya.



Figure 6: The uses of the public space during the 04.00pm-06.00pm at the weekend

5.2 Observation of the user's behavior and activities in 7 sub-areas of the case study

The data from observation of the user's behavior in each sub-areas was recorded at the time 04.00pm-06.00pm at the weekend. By using the behavior map, to identify the location of the activities and amounts of users which were represented in different color points. The maps also show the circulation inside the study area



Figure 7: The behavior maps of 7 sub-areas (drawn by author)

And from the Table 1, the data from observation can be described the usage quantity of each activity in 7 sub-areas during the most heavily use time, 04.00pm-06.00pm on Saturday and Sunday. In terms of the location of the activity, the frequency of use per day. To find out and conclude the total usage quantity of Pattaya beach road public space in the most heavily use time.

Area	Usage Quantity of Each Activity in The 7 Sub-Areas during 04.00-06.00 PM on Saturday - Sunday.							
Activity	1	2	3	4	5	6	7	Tot al
Walking	15 (4.13%)	40 (11.01 %)	49 (13.49%)	82 (22.58 %)	77 (21.21 %)	53 (14.60 %)	47 (12.94 %)	363 100) %)
Jogging	4 (21.05 %)	2 (10.52 %)	5 (26.31%)	5 (26.31 %)	3 (15.78 %)	(0%)	(0%)	19 100) %)
Standing/ Sight Seeing	12 (5.50%	31 (11.84 %)	68 (31.19%)	29 (13.30 %)	49 (22.47 %)	20 (9.17%)	9 (4.12%)	218 100) %)
Sitting	27 (14.59 %)	33 (17.83 %)	11 (5.94%)	39 (21.08 %)	40 (21.62 %)	24 (12.97 %)	11 (5.94%)	185 100) %)
Picnic /Sitting on Ground	3 (2.5%)	14 (11.66 %)	32 (26.66%)	31 (25.83 %)	17 (14.16 %)	6 (5%)	17 (14.16 %)	120 100) %)
Total of Usage Quantity	61 (6.65%)	120 (13.10 %)	165 (18.01%)	186 (20.30 %)	186 (20.30 %)	103 (12.47 %)	84 (9.17%)	905 100) %)

Table 1: The usage quantity of each activity in each sub-areas during 04.00pm-06.00pm at the weekend.

(1) The areas which have the most usage quantity are Area no.4 Plaza at the middle Pattaya, Area no.5 Plaza opposite the Central Festival Pattaya Beach (Department Store). Both of the plazas have the same percentage of the total usage quantity, 20.30% of the total. Because the area has the elements that provide the opportunities to use the area such as the seating at the edge of the plaza and the sculpture with the seat around the base. Moreover, the physical elements, the location of the plazas is located nearby the district of commercial stores, bars and also the accommodations which appeal a lot of people to come and the atmosphere of the area is bustling and vibrant. (Figure 8)

(2) The area which has the least usage quantity is: Area No.1 Plaza at the north Pattaya. The plaza has the percentage of the usages about 6.65% of total usage quantity of Pattaya beach road public space. The reasons that make this area has the least usage quantity might because of the privacy atmosphere of the accommodations nearby and

also the location of the plaza is far from the district of commercial stores/bars, then the overall atmosphere is not being active as similar as the other zone of surroundings context along Pattaya Bay. (Figure 9)



Figure 8: The use of the area no.4 and no.5 which are the area with the most usage quantity. (Source by the author)



Figure 9: The use of the area no.1 which are the area with the least usage quantity. (Source by the author)

Acitivity	Percentage of Usage Quantity	Amounts of Usage
1. Walking	39.62%	363
2. Jogging	2.07%	19
3. Standing/Sight Seeing	23.79%	218
4. Sitting	20.19%	185
5. Picnic/Sitting on Ground	14.30%	120
Total	100%	905

Table 2: Summary of the public space usage amounts of each activity during 04.00pm-06.00pm at the weekend.

(3) The activity which has the most usage of doing is: Walking, with the percentage of usage quantity, is 39.62%. Because of the overall physical characteristics of Pattaya beach road public space is the linear public space which has the main function in term of walking corridor along the beach and people also came out to enjoy the scenery of Pattaya beach and heading to the nightlife district.

(4) The activity which has the least usage of doing is: Jogging, with the percentage of usage quantity, is 2.07%. The reason that jogging is the activity with the least usage, the public space did not design the pavement or running track in the proper way which should be clearly separated from the walkway. And also be provided the width of the walk/running track consistently.



Figure 10: Walking, the active activity which has the most usage of doing in the Pattaya beach road public space during 04.00pm-06.00pm at the weekend (source by the author)

5.3 Analysis of the physical design elements of the Pattaya beach road public space in accordance with the design guidelines for good public space.

From the literature review, the 12 quality criteria for good design of public space by Jan Gehl was chosen to be a tool in comparing analysis with the physical design elements of Pattaya beach road public space. The topics of interest are including 1. Protection 2. Comfort and 3. Enjoyment, and found that there are some consistency issues with the following details:

Protection	Comfort	Enjoyment
	- The plazas can be	
 Lack of access facilities, such as crossing way or transition space. The boundary between the area and the road is divided only by the elevated pavement, no fences or barrier The bustling atmosphere and open space make the area can be able to see and ensure the security. Plants provide shady area but cannot protect users from bad weather 	 easily accessed from the walkways but in Area no.1 was not designed the transition approach between the outside path and the beach road public space. The areas are all connected with the walkways and other parts of the public space The areas have the seating around the sculpture but insufficient inside the plazas The locations are conducive to able to see the good view of Pattaya Bay 	 The size of the plazas area is related to the human scale, except the area no.4 which is too large and make people feeling unpleasant. The surface materials are placed in the different patterns which make the area looks interesting. The tropical plants are the important elements that are consistent with the surrounding atmosphere.
- The walkways are all separated from the vehicle lanes with no fences or barriers to protect the users, but the width of the area can make more safety to walk except area	 The width of the area is wide enough for a traffic except for area no.7 which is narrow and has too many obstacles. The surface of pavement are all 	- The tropical plants are the important element which makes the walkways appeal people to walk along and create
	 Lack of access facilities, such as crossing way or transition space. The boundary between the area and the road is divided only by the elevated pavement, no fences or barrier The bustling atmosphere and open space make the area can be able to see and ensure the security. Plants provide shady area but cannot protect users from bad weather The walkways are all separated from the vehicle lanes with no fences or barriers to protect the users, but the width of the area can make more safety to walk except area no.7 	 Lack of access facilities, such as crossing way or transition space. The boundary between the area and the road is divided only by the elevated pavement, no fences or barrier The bustling atmosphere and open space make the area can be able to see and ensure the security. Plants provide shady area but cannot protect users from bad weather The walkways are all separated from the vehicle lanes with no fences or barriers to protect the users, but the width of the area can make more safety to walk except area no.7 Area no.1 was not designed the transition approach between the outside path and the beach road public space. The areas are all connected with the walkways and other parts of the public space The areas have the seating around the sculpture but insufficient inside the plazas The locations are conducive to able to see the good view of Pattaya Bay The surface of pavement are all smooth, no level

Types of Sub-Areas of	The Quality Criteria for Good Design of Public Space			
Pattaya Beach Road Public Space	Protection	Comfort	Enjoyment	
Promenade between the middle and the south of Pattaya	 Lighting is installed along the area but still have some blind corner. Plants provide shady area but cannot protect users from bad weather 	changed too much - The areas are lacking of the elements which support the other uses such as seating area, street furniture, etc.	atmosphere. - The walkways have a simple format which is not complicated in pattern or shape.	
3.Memorial Place - Area No.6 Royal Varuna Yatch Club Memorial	 The area of the memorial place is clearly divided from the road with the existing walls, but in the walkways has no fences or barriers to protect users. The area is an open space that provides the possibility of seeing and makes users feel more safety The area is lack of the shelter or the sky cover elements. 	 The area can be easily accessed from the walkways on the public space, but there is no transition space between the opposite sides of the road. The secondary seating in the area is the main element that promotes the use of the space. The wooden terrace is contributing to lean or stand and take a sightseeing. 	 The physical character of the area is different from the other parts of public space, which was designed to use the variety of the materials and shapes. The size of the area is consistent with the human scale, not too large but might be too narrow when there has the heavy usage. 	

Table 3: Conclusion of the analysis the physical design of Pattaya beach road public space in accordance to the quality criteria for the good design of public space.

6. Conclusion

This research analyses the results of an investigation in Pattaya Beach Road Public Space, Pattaya Bay, Chonburi Province, Thailand into the tourists and local citizens' aspirations for different types of beach road public space that related to the social functions and user's activity. The results will serve in the improvement of urban public space for making the public space become the place for people who come to use in many activities and be related to the characteristics of urban context which will contribute urban greenery system planning in Pattaya city.

In case of Pattaya beach road public space, the quantity of use and the limitation of the number and several of activities are caused by the spatial condition which could not respond to the real need of users. Some activities are taken in the wrong places like people and tourists are standing and waiting to get in the tourism speedboat on the paving. Some place and elements of public space are properly unused and inattentive while some other are over capacity, like Plaza at North Pattaya where's no good access to use, Pedestrian and another plaza that have a lot of people and no place to take a seat or place for take an ocean view to enjoy the moment, and also lack of the space for doing exercise and other recreations.

By the analysis also found that there have many factors which influence the uses of the public space, like the surroundings activities in the context of Pattaya Bay which are different from the North Pattaya to South Pattaya. The north Pattaya is the accommodation zone, The Middle is the mix-used district between the accommodations, bars and commercial stores, and in the south Pattaya is the most active nightlife entertainment district. Moreover, there have the physical landscape design elements such as the good accessibility, the beauteous scenery from the ocean and sunset view, the shading from the plants and trees that make the properly climate, the appropriate dimension of space which have a lot of potential for making people to come and use, and also the elements that makes the people being secured like the lights, the security cameras, and the police boxes.

Design Recommendations

The brief description of design and amenity changes recommended to improve the quality of settings as a place for people to use and enjoy in Pattaya Beach Road Public Space are:

1. Quantitatively, the public space should be provided the space and well distributed in each cluster or zone of the surrounding buildings in appropriate size needed and suitable the density of users and population, such as the sitting area, the place for taking an ocean view and the walking corridor (plus jogging trail and bicycle lane)

2. The functions of the space for each activity should be re-arranged and distributed in term of the privacy and avoid the disturbance from the different activities.

3. In case of the microclimate is very hot, it should be more vegetation and canopy for shading the area and cover the user from the rain, especially in the Plazas.

4. Night lighting is the important element that should be added more in the public space, especially in the blind corners and along the promenade.

5. The transition space at the both ends of the beach road public space should be designed for making the good and continuous access and giving some elements to approach people.

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Building Community: Stepping Beyond Typical Large Scale Housing Development Models to Create Better Rural Communities

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Abstract

Community is a vital aspect of living, yet most large scale housing developments tend to focus on achieving maximum occupation rather than creating environments within which communities can grow and thrive. This paper explores the key characteristics of large scale (and post disaster) housing developments in Sri Lanka, and their impact on the culture of rural communities. This paper argues that large scale housing developments should not merely be about providing houses; instead, the focus should also be on the creation of vibrant community environments, and community living spaces. In other words, the paper argues for the significance of spaces in between and around houses, and the effect of these on the wellbeing of people and the progress of the community. The paper identifies several thresholds of 'community living space' based on traditional, cultural and livelihood practices and discusses the architectural opportunities of these and their value and significance in creating better living environments. The paper concludes with comment on the value of placing a far greater focus on community space planning and design, particularly in low cost housing developments in rural Sri Lanka.

Keywords: Reconstruction, Housing, Relocation, Community, Traditional, Rural

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Introduction

Housing projects cater to the needs of various sectors of society and are constructed for diverse reasons. Hence they have to satisfy the equally diverse needs of all their stakeholders, including providers and residents. The construction of low cost housing after a wide scale disaster, such as the 2004 Tsunami, are predominantly aimed at providing homes for destroyed communities within a short span of time, with the ultimate intention of life returning to a level of normalcy similar to pre-disaster states. However these projects are also seen, especially by governments, as an opportunity for intervention in the economic development of these disaster affected regions so as to transform them rapidly from a rural to an industrialised economy (Oliver, 1992; Barakat, 2003). Commenting on the negative outcomes such government attitudes generate in post disaster situations Paul Oliver, states, 'the notion of 'development' as a process of transition from a predominantly peasant economy to an industrialised one is of relatively recent date' (Oliver, 1992). The sustainability and suitability of such developments for the needs of homeowners and communities are most often assumed and the industrialisation and development aimed for (Oliver-Smith, 1992), at least in the first instance, is the priority. Oliver observed the negative implications of government interventions on rural communities in the 1970s and 80s. Four and a half decades later government approaches to reconstruction have not changed and continue to force the rapid transformation of rural regions, traditional communities and vernacular living environments in the aftermath of disasters, into new and unrecognisable places. While it is understandable and justifiable that the underlying aim of governments is the economic improvement of poor communities, the processes utilised to achieve these aims fail to yield the desired outcomes in both the short and long term. The predominant reason for this is the lack of understanding of contextual opportunities and cultural practices that support livelihoods and sustain these communities.

Post disaster developments concentrate on one aspect—rehousing as many people as possible in a short time. These interventions are often implemented by organisations with little or no prior experience in such work and with little or no contribution from future homeowners. As a result they rarely respond to the socio-cultural needs and environmental aspects of rural communities, hence failure is inevitable. Oliver (1992) believed these interventions are 'predicated on the belief that the victims of a disaster should be provided with housing as they may be provided with medicines, blankets or food' (p.15) and that 'housing is largely based on the concept of the dwelling as a consumer product and marketable commodity; the separation of owner and builder is assumed' (p.15). The large body of literature that has emerged over the last decade from disciplines such as Psychology, Environment and Behaviour, Geography and Livelihood Studies, Landscape and Ecological Engineering highlight the shortcomings of these developments and the psychological, physical, economic and social impacts on traditional and rural communities. When combined with the issue of the infrastructure needed to support new developments and sustain communities rarely materialising these developments are akin to a second wave of disasters.

The aim of housing developments in Sri Lanka after the 2004 Asian Tsunami was to provide basic homes to entire communities by relocating them inland and away from traditional coastal environments, now considered unsafe. Following the extensive destruction of life and property caused by the 2004 Tsunami in Sri Lanka, over 500 donor organisations pledged to assist by rebuilding the near 70,000 homes (Tittawella, 2005; World Bank Report, 2009) estimated to have been damaged or destroyed. Most of these donor organisations and the architects and planners they worked with had little or no previous association with the communities they were rebuilding, or any prior experience in community housing or rural development in Sri Lanka or elsewhere (Shaw, 2011).

Efficiency is the usual driver of development projects whether funded by governments, donor organisations or the corporate sector, for time and resources are costly and these organisations have other agendas to deal with. As a result, generic housing typologies and community layouts designed for ease of construction in early post WWII western suburbs are privileged and transplanted with no consideration for contextual uniqueness or the sustainability of communities. Most post Tsunami housing in Sri Lanka was based on these unsuitable and outdated models. Observing this situation Fabry, founder of Sri Lanka Solidarity working for the economic development of poor communities, states 'It should not be a matter of just putting people into houses in empty paddocks but of thinking how these communities might be operating in 10 or 20 years time' (Shaw, 2011, p.8).

The Study

This paper is one outcome of a study carried out over several visits to Tsunami affected communities in southeast Sri Lanka between 2005 and 2008. The initial study was conducted a year after the 2004 Asian Tsunami. Visits were made to several displaced communities housed in temporary shelters while their new housing was being constructed.

Informal interviews, casual meetings with various community members and observations enabled a view of these disaster affected communities from a perspective not normally available. This data was all recorded for later consideration. Displaced from their usual living environments, with their homes, families, communities and livelihoods destroyed by an unimagined natural disaster of immense magnitude, these people were at their most vulnerable. However they were a humble, warm, generous and welcoming people, eager to begin rebuilding their lives, livelihoods and communities and determined to put the disaster behind them and resume a normal life. In this sense they were an incredibly resilient people.

The same communities eight months to one year later had moved to their new houses and were coming to terms with their new living environments and starting to take ownership. Relocated 700m to 5km from original sea front living and livelihood environments, the communities were completely new in terms of their layout, house types and materiality. Six months into occupation of the new living environments obvious adaptations and changes to the new housing were evident as was the change in the attitudes of community members. It was clear that what had been constructed for these people, mostly with little or no input from community members, was inadequate, lacking in fundamental infrastructure and not aligned with their basic needs or the contextual conditions.

As I wandered through the communities observing the changes, adaptations and additions to the new housing I was also able to observe the community in their daily activities, interacting with each other and the new living environment, and the changes they had made to it. This research is the outcome of my attempts to understand the changes and identify what was driving these. As I began to understand the relevance of the changes and the difficulties communities were facing in new developments the question 'how do we overcome the disconnect between research published on the significant damage post disaster developments cause to communities, and the governments, donor organisations, community planners, and architects who continue to implement outdated and unsuitable developments?'

The aim of both the study and this paper is to open up a discourse on how we might change current attitudes and approaches to reconstruction and focus on rebuilding the lives of disaster affected rural communities, and facilitate this through informed creative spatial planning and design methods to achieve:

- a. living environments that are appropriate to rural economies and traditional livelihood practices
- b. living environments that support community engagement and capture the unique qualities of traditional and rural living
- c. housing solutions sensitive to the contextual conditions, needs and livelihoods of traditional and rural communities
- d. housing solutions that are easily adaptable by community members and utilise vernacular materials and traditional methods familiar to them

This paper evolves through a series of discussions. It begins by identifying the common characteristics of housing developments in emerging nations like Sri Lanka following a large scale disaster. This is concluded by identifying the effect of these developments on the lifestyles and needs of traditional rural communities. Thereafter the discussion focuses on understanding the traditional, and now destroyed, living environments of rural coastal fisher communities and highlights the spatial qualities that once supported the basic living and livelihood needs of these fisher communities and the factors that shaped them. The aim of the paper is to highlight the differences between the housing provided to these communities after the Tsunami and the living environments that were familiar to the coastal fishers.

Common characteristics of Post Disaster Developments

Common characteristics of large scale post disaster community developments at the neighbourhood scale are set out in table 1 with a commentary on their key characteristics and implications for traditional and rural communities. Table 2 looks at the housing built after a disaster in a similar manner.

Table 1: Common Characteristics of Post Tsunami Housing Developments

Characteristic	Commentary
Relocation	Forced relocation out of traditional living
	environments, food & livelihood sources to safer
	& new environments. Disruptive of traditional
	family, community & livelihood structures. No
	consideration for future sources of income and
	long term sustainability. Insufficient resources,
	poor or unsuitable infrastructure, transportation
	issues, increased cost of living
Gridiron layouts	Layouts impose uniformity, orderliness, control,
	surveillance & tidy appearances. Equalising and
	flattening of community hierarchies, cultural
	structures & diversity. Ease of subdivision &
	allocation of land, Ease of planning, construction
	and supply of services
Privileging the Street	Community layouts controlled by streets, not
	necessarily in response to vehicular access needs
	of the community (bicycles, tuk tuks, motorbikes,
	van) but to generic urban planning models.
Privileging of Services	For ease of constructing services (water, power
	etc) privileged over organic layouts of traditional
	& rural communities
Community Space	Located in central communal areas and catering
	for the larger community. Lack of small spaces
	for clusters of community. Ensures economy of
	land use & ease of planning but fails to provide a
	sense of security and vigilance, particularly for
	the safety of children.
Contextual Uniqueness	Site cleared completely and flattened where
	possible with only a few distinguishing factors
	left, such as larger trees, if any: site
	identity/character lost/deleted. Provides ease of
	planning and construction.
Boundaries	Extensive boundaries between homes and
	between homes & community spaces

Characteristic	Commentary
Generic House	2-4 house types with minor variations & 4 room house model consisting of kitchen living 2
	house model consisting of kitchen, fiving, 2 hedrooms + outhouse or externally accessed toilet &
	shower.
Orientation	House orientation informed by gridiron street layouts
	with houses facing streets, this affects cooling,
	protection from monsoons, cultural beliefs &
	practices.
Low Cost Construction	Use of labour intense methods and systems.
	Unsuitable & poor quality materials with high
	transportation costs as not locally produced.
	unality assured. Testing ground for new construction
	methods and imported materials
Detail	Poor consideration for details, missing elements that
	mitigate contextual environmental factors such as
	pitched roofs, wide eaves, deep verandas, and
	balconies for shade from rain and sun & suitable
	penetrations for cross ventilation & increased air
	flow for natural cooling & privacy. Raised floors in
	flood prone sites
Materials	Construction materials unsuitable for contextual
	conditions, not locally available and uniamiliar to
	adaptation difficult & costly
Living Space	Missing key living spaces such as verandas
~p	(relevance discussed in Table 4), kitchens suited to
	traditional food preparation methods, storage suited
	to livelihoods & bathrooms & toilets suited to local
	culture.
Adaptability & flexibility	Roof forms, house layouts, construction methods
	either do not allow or limit opportunity for
	expansion or additions.

Table 2. Common Characteristics of Post Tsunami Houses

Common shortcomings that contribute to the issues outlined in the above tables may be identified in the typical approaches taken by governments and donor organisations in a post disaster situation. Top-down planning approaches, directed and driven by those with little or no prior understanding of these communities and often unable to distinguish one village from another, seriously undermine the highly complex systems of living and contextual uniqueness that define rural communities. The lack of understanding and appreciation of the difference between urban and rural planning is another factor that underlying unsuitable rebuilding processes and unsustainable developments. Rural communities function differently to urban communities and do not have the same levels of income, population density, resource consumption and
infrastructure requirements. Planning guidelines and design requirements for rural environments must reflect these differences and respond to the uniqueness and future potential of these environments. Not heeding research into these post disaster communities and isolating them from the detailed planning and construction processes are identifiably the biggest contributors to unsuitable developments and the key shortcomings needing to be addressed.

Implication	Impact
Identity	Generic identity: nonspecific to community,
	place, livelihoods, contributing to a sense of lack
	of identity or loss of identity
Uniformity	Equalising or flattening of hierarchies, negating
	the diversity and uniqueness that inform
	community, and contributing to a sense of loss of
	identity and displacement
Newness	Unresponsive to community dynamics and space
	needs: isolating and unsupportive environments
	threaten sense of community and family, lack of
	in-between semi-public communal space, safety
	of children compromised, opportunity for
	strengthening family and livelihood networks lost
Space	Inadequate spatial allocation: vastness of
	development, wide streets, large subdivisions,
	spread out communities contribute to isolation,
	lack of security, loss of sense of safety,
	loneliness, travel & transport issues, services and
	access to resources & facilities. Inadequate space:
	contributing to lack of privacy, inability to carry
	out daily & livelihood activities and support
	extended family, contributes to health & hygiene
DI	Issues Delegations formed new contributes to loss of
Place	Relocation: forced removal contributes to loss of
	identity relative place of significant meaning to
	Displacement and loss of control of traditional
	biographics livelihood networks sources and
	locations loss of income threatens community
	sustenance & sustainability
Privacy	Differing notions of privacy and security:
I IIVaCy	community is unfamiliar with these. This can be
	isolating inadequate or inappropriate

Table 3: Implications and Impact of Housing on Traditional & RuralCommunities

While the long term physical, psychological and economic impacts of post tsunami housing projects on Sri Lanka's traditional and rural communities is yet to be studied

similar studies have been carried out in rural environments of developed nations, following relocation and rebuilding processes after major disasters (Quarantelli, 1985a, 1985b; Brown, 1992; Riad, 1996). These studies provide valuable insight into the approaches to post disaster situations across developed nations and the consequences of these on communities and individuals. When compared to the processes in emerging nations there is little difference; relocation, unsuitable housing, lack of understanding of local cultures and livelihood needs also dominate these projects. Forced relocation is identified as particularly disruptive and psychologically stressful across diverse contexts and cultures (Oliver-Smith, 1992). This is further aggravated by unsuitable housing and the breakdown of family networks and community structures (Quarantelli, 1985a, 1985b). In addition the complex relationship between place and livelihoods when disrupted through relocation is rarely recovered (King, 2011). This is a major finding as it highlights the impact on the economic wellbeing of the family and community and in particular the psychological wellbeing of the family breadwinner, usually the dominant male (Quarantelli, 1985a, 1985b). The negative physical, psychological and economic impact of relocation and unsuitable housing on disaster affected communities discussed in these studies highlights the seriousness and caution required when intervening in the reconstruction of housing and development of disaster affected communities (Riad, 1996).

Through these studies we can begin to understand how and why these developments are failing to provide living environments suited to individual and community needs. What appears to be lost through unconsidered reconstruction interventions are the complex spatial relationships that sustain invaluable connections between family, extended family, friends, livelihood networks, livelihood sources and traditional place.

Housing Traditional Communities: Understanding Shortcomings and Inadequacies

When living and livelihoods are closely intertwined, when day to day survival is the prime purpose of life, every little handful nature offers must be embraced, cherished and lived through. Before the 2004 Tsunami destroyed traditional coastal communities in Sri Lanka, they lived predominantly off the land, rivers and sea. These communities were involved in a wide range of livelihood activities related to the fishing industry and were mostly traditional in outlook, technologies and lifestyles.

Traditional communities evolve over time and are established around food sources or livelihood opportunities. With time they may be arranged and structured according to family and livelihood networks, intricate caste structures, caste defined social roles, traditional belief systems, ethnicity, religion, and even historic disputes. Traditional and vernacular homes are most often constructed by the home owners themselves based on family and livelihood needs and in response to contextual conditions. These homes are generally located within close proximity to the main family home, and homes of immediate or extended family members or friends. The building of a new home is a significant occasion for the family and the community. It involves religious and traditional rituals and its construction is governed by the astrological alignments relative to the new homeowners. Similarly the placement of the house on the site and its orientation are informed by traditional beliefs, including placement of the front door, internal doors, and roof beams. The construction of a home involves the community: family, friends, community members with building experience, women, children and religious and cultural leaders. Getting everything right gives the family great opportunity at lifelong happiness, good health and prosperity. In this sense the home is unique to its owners and is for their lifelong inhabitation and is very much a part of the community that participated and contributed to its manifestation. This concept is at odds with the notion of house as a commodity where the homeowner and the community are isolated from its planning and construction until they are invited to occupy it on completion. While the notion of 'gifting' and 'charitable' endeavour sits well with the donor, it does so with the recipient only for a limited time.

Understanding and respecting the uniqueness and differences of housing needs is essential for identifying suitable and sustainable approaches to assisting communities recover after disaster.

Rural Traditional Living Environments of Sri Lanka's Coastal Fishers

The living environments of the coastal fishers of Sri Lanka can be broadly distributed across several thresholds, each catering for specific functions and needs while blending into the others. It is this collection of thresholds and the collaboration between them that contributes to the fisher's notion of home and community. 'Malu Wadi', the Sri Lankan term for a fisher community, refers to a place where fishers dwell and fish production occurs concurrently (De Sylva, 2008). To the coastal fishers, home and workplace are not two separate entities. The malu wadi' is a community centred on traditional livelihood activities which occur around home and involve family and community (De Sylva, 2008). This relationship is further reinforced by the proximity of home to the livelihood source, the sea, and the point at which income is earned through the bartering of the daily catch, the shore (De Sylva, 2008). Traditionally the malu wadi was a collection of loosely arranged thresholds of open or semi-enclosed space for various community and livelihood activities, surrounded haphazardly by structures for sleeping, cooking, and storage constructed using vernacular materials such as woven coconut palm leaves (De Sylva, 2008). The basic thresholds of a fisher home align with a number of common spatial terms associated with domestic living and public space, however their functions differ from those the fishers associate with them. The 5 key thresholds of a fisher home are identified and described below in table 4.

Table 4: Fisher Home

Spatial Threshold	Description
House	An indoor space where bedrooms are a private
	secure interior for the sleeping of women &
	children & the storage of valuables. Living rooms
	are semi private often symbolic spaces
	demonstrative of status & economic prosperity &
	translate easily to fit family activities & sleeping
2	at night
Step	A semi-private space that corresponds with the
	primary living spaces of the house where daytime
	household activities take place such as food
	preparation, eating, entertaining, socialising,
	The star of the divides the bases from the form the
	The step often divides the nouse from the front &
	rear garden, the kitchen and tollet from internal
	dock and courtward correspond with stop
Candon	The semi private space houses socialising
Garden	children's play livelihood related activities (shop
	net renairs coir production) home gardens food
	preparation drying cleansing & outhouse
Shore	A semi-public territorial place with boundaries
	recognisable to the community, for livelihood
	related community activities, trade, storage (boats,
	net & equipment), community interaction, social,
	recreation.
Sea	A semi-public territorial place with boundaries
	recognisable to the community that support
	traditional food source & livelihoods, and
	recreation

Academic literature informed by westernised notions defines house and home as an 'interior space' for household activities circumscribed by the walls that contain it (Sime 1993). A study on home gardens by Jonathan Sime redefines these boundaries and extends them out to include the garden. Sime claims the garden as a psychological space within the territorial bounds of home and stresses its importance to the concept of dwelling. This is one of the few studies that challenge the widespread westernised notions of home as a walled-in interior. This study enables us to begin to appreciate the notion of 'openness' as informing the concept home and to understand the thresholds of openness that inform the fisher's notion of home.

While the 'Step' is a spatial threshold commonly seen in the architecture of most nations, the activities the coastal fishers associate with it as outlined in Table 4 are unique to their requirements, and may vary in form based on cultural and climatic conditions. This vital spatial element of a fisher home when combined with 'House'

and 'Garden' inform the family's identity and basic sense of dwelling. In addition this spatial threshold is easily accepted as what constitutes home by most societies, although it is rarely considered an essential space in low cost housing. To the fishers, however, this is a vital threshold and the concept of home is only satisfied if it is included.

Shore and Sea are the psychological and territorial boundaries that inform the fishers' world-view and sense of community. The spatial definitions of these two categories correspond with functions related to livelihood activities which involve not just the household but also the community and the wider community, this being essential for supporting livelihood and income. The boundaries of this threshold are recognised and respected across traditional communities; fishers from one community would not fish in the traditional territorial waters of another. This was explained by community members as a way of ensuring not just the prosperity of each community but also the prevention of exploitation through over fishing or use of damaging fishing techniques. The fisher's concept of dwelling is only satisfied if it includes Shore and Sea. Relocation after the Tsunami impacted negatively on the fishers and their livelihoods, mostly due to the separation from territorial place and inability to monitor territorial waters for both fishing opportunity and violations.

Discussion

As one observes fisher communities in their day to day activities it becomes evident that the thresholds that form their living environments are informed by complex traditional, socio-cultural and livelihood requirements, and are a response to climatic conditions. Notions of privacy, enclosure, spatial activity and sense of ownership differ significantly to common westernised notions. From the studies carried out it can be concluded that the architecture of the fishers is one that extends between land and sea and is defined primarily by openness (De Sylva, 2008). This is a concept that eludes the understanding of most urban dwellers and those that attempt to rebuild these communities after disaster. It is also important to note that what is provided is described as new housing, rather than new homes. 'Home' is often defined as possessing greater meaning and significance to the occupant than 'house' (Lawrence, 1987; Norberg-Schultz, 1980; Dovey, 1985). A 'house' to be considered a 'home' must satisfy specific needs particular to individuals and communities, and these needs are informed by culture, occupation and worldviews. The notion of "dwelling" is broadly defined by Lawrence (1987) and Norberg-Schultz (1980), as the link and process that fosters place attachments that enables the experience of house as a home. These studies also suggest that for one's existence on earth to be meaningful, place attachments that foster a sense of belonging and purpose are essential.

Individuals interviewed at case study sites directly linked their sense of disorientation and lack of motivation for resuming their livelihood activities after resettlement to their displacement from traditional living environments and the new housing. They identified the inadequacy of new housing developments in conveying their status within the community, disrupting vital community relationships, and dislocation from the coastal edge as the cause. In traditional community based livelihood activities, the role of the individual informs their responsibilities and status within the community and vice versa. For these displaced people the prospect of a new beginning without a past, or even a symbolic representation of it, was an alarming challenge.

Individuals interviewed at a second study site of 150 standardised houses, laid out in a grid, were able to map settlement patterns of occupation based on traditional caste and social hierarchies which were otherwise not discernible to outsiders. Maintaining traditional caste structures and social hierarchy, even after a disaster, appears to have been important to these communities. Social structures no doubt reinforce relative group worth to these communities, and were seen as essential for psychological recovery and for the resumption and continuity of livelihood activities and daily living.

While the brief discussion above enables us to begin to understand the shortcomings of the more widespread westernised understandings of house and home, it also enables us to appreciate the basic needs of traditional and rural communities.

Concluding Discussion

Research outcomes from diverse communities across a range of nations, first world and emerging, all point to the same negative physical, psychological and economic outcomes when communities and families are rehoused in environments that are significantly different to those they are familiar with. The issues related to developing housing for the poor, particularly for traditional rural communities affected by disaster, has been highlighted in over three decades of published research from the architecture discipline, yet the same mistakes continue to be made. Similarly research from a range of disciplines highlights the negative psychological, physical and economic impacts of relocating and rehousing communities on traditional living environments and livelihood locations. Loss of income due to difficulty in recommencing livelihoods, disconnection from place and disruption to vital family and livelihood networks have been identified as the significant long term impacts of relocation, and these are compounded by unsuitable and poor quality housing.

The intricate and complex support networks that exist in traditional rural communities are rarely understood and appreciated for the significant role they play in assisting in recovery processes after a disaster and sustaining communities in the long term. Similarly the relevance of place to traditional communities and livelihoods, for the same benefits they offer, has not been understood. The short-sighted and ignorant attitude and approach to housing of rural and traditional communities is led by the view that urban development principals can be applied to rural communities. The lack of awareness and understanding of how rural communities are structured and how livelihood practices differ from urban livelihoods continues to afflict post disaster planning. This situation must change if housing is to continue to be the driver of reconstruction endeavours.

Interaction and engagement with place and context defines rural and traditional community as do the environmental factors with which the community is familiar and

comfortable. Livelihood activities and choices are informed by the opportunities the wider community, place and environment presents. Traditional communities, even though linked by several obvious similarities, differ from each other. Common factors that act as links are the subtle yet complex community structures, religious beliefs, cultural practices, ethnicities, relationships to place and livelihoods. While these may also act as differences between communities they are highly respected and adhered to by traditional community members. Home based small industries such as fishing, agriculture and manufacture of products for sale and community use are the main sources of income, and these industries are most often place dependent. Living in close proximity to family, extended family, friends and means of livelihood strengthens these communities. As a result these tightly linked communities are resilient as a group and have a higher probability of being self-sustaining. Forced relocation disrupts these attachments and valuable networks and undermines the opportunities of affected communities for fast recovery, while exposing them to future psychological and social vulnerability and economic poverty. As published research has advocated for several decades, relocation should be a last resort in a disaster situation and should be voluntary.

Governments and local councils motivated by political agendas aim at a 'uniform' development model across rural environments and advocate for this when funding opportunities for development are presented, particularly after a disaster when external and international funding opportunities are offered freely through donor organisations and international governments in the form of humanitarian aid. Donors with little prior knowledge of the communities and rural environments, and due to time constraints, align themselves with local governments and councils to deliver quickly on their pledges. The common approach to reconstruction of rebuilding houses rather than communities and livelihoods, perhaps driven by the measurability of outputs, is privileged by governments and donors. Re-establishing community ties and livelihoods is shown in the literature as the quickest way to recover after a disaster and the most sustainable, however building housing is privileged. Development after a disaster should focus on facilitating the recovery of the community by supporting the re-establishment of disrupted food sources and livelihoods and identifying ways to increase the resilience of communities.

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Developing an Economic Analysis Application for Solar Rooftop Electricity Generating in Thai Residential

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Abstract

This paper presents the development of an economic analysis application for solar rooftop electricity generating in homestead. This study focuses on extracting specific parameters of solar rooftop system in residences and finding indicators of cost analysis and economic benefits to design and develop an application for solar rooftop system and economic analysis by using Visual C#. This application can reduce the complexity of the investment calculation of the solar rooftop system and also reduce human error from manual calculating by only input the location and the dimension of the plant area to get the result. The Graphic Design Interface (GUI) was designed in Thai language to help Thai people who are interested in the solar rooftop project to be able to analyze the economic benefits by themselves. The default of the calculation is to use the parameters of Poly Crystalline Silicon (c-Si) which is popular in Thailand and the information on the solar radiation value in each area from The Department of Alternative Energy Development and Efficiency of Thailand. So, the results from this application can represent the real value of each area in Thailand. In addition, the user can vary the technical parameters and economics costs, which could make the result more accurate, so that people can choose an acceptable investment by themselves.

Keywords: Solar Rooftop, Solar PV economics, Solar PV application, Visual C#, Software packages.

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Introduction

In Thailand, the Renewable energy and alternative energy are beginning to play a role in Thailand's power generation system. One of the important factors for Thailand to consider using renewable energy is: The problem of global warming is likely to increase. Due to the greenhouse gas (GHG), most of which is carbon dioxide (CO2) produced by the combustion process of fossil fuels. In various industrial processes. Including the fossil-fuel-based power industry to generate electricity. Therefore, the government has made efforts to push for alternative energy development is more concrete. To make a forward to a low carbon society following in Figure 1.



Figure 1 : AEDP2015 Plan and CO2 Emission Target

In terms of electricity from solar energy. It is evident that the government has recognized the importance and support of many policies. The government has launched a policy to encourage people to invest 2006. And in the year 2559 a pilot project, the production of solar power is free. It is evident that the government has issued a continuous stimulus policy following in Figure 2. However, the solar-power projects in the public sector still do not meet the target. Because the factors that influence consumers decision to invest in solar rooftop solar roofing systems have been investigated. The factors influencing consumers investment decisions are: Installation costs and payback period. This study has the idea. If you can make public access to the calculations about Cost of installation and payback period is easy. It can help people make more informed decisions. And if investor can design a program to help analyze the economics and solar power in simple and Thai language. It will give people access to information and can help to make investment decisions.



Figure 2 : Timeline for Government support policy in Solar Energy

This study focuses on extracting specific parameters of solar rooftop system in residences and finding indicators of cost analysis and economic benefits to design and develop an application for solar rooftop system and economic analysis by using Visual C#. This application can reduce the complexity of the investment calculation of the solar rooftop system and also reduce human error from manual calculating by only input the location and the dimension of the plant area to get the result. The Graphic Design Interface (GUI) was designed in Thai language to help Thai people who are interested in the solar rooftop project to be able to analyze the economic benefits by themselves. The default of the calculation using data from Ministry of Energy of Thailand. So, the results from this application can represent the real value of each area in Thailand. In addition, the user can vary the technical parameters and economics costs, which could make the result more accurate, so that people can choose an acceptable investment by themselves.

The Basic Assumption of program

1. The program use data about Global Radiation from database of Ministry of Energy of Thailand shown in Solar Map Figure 1

2. Default of Investment Cost use Cost from database of Ministry of Energy of Thailand shown in Figure 4. But it is can change.

3. Default PV Type is Poly-Crystalline. But it is can change to Multi-Crystalline or Thin-film shown in Figure 5.

4. Default Tilted Install Angle on the rooftop is 15 degree. But it is can change.

5. Default Performance Ratio of System is 85%. But it is can change.

6. Default Operation Temp of PV is 60C. But it is can change.

7. Life Project is 25 Years.



Figure 3 : Global Solar Radiation of Thailand

		Rooftop	PV Fact	Sheet		
1. เงินลงทุนในระบบ		60,000 ארע/k	W			
2. ขนาดพื้นที่ที่ต้องการอย่างน้อย		7 m ² /kW _p				
3. น้ำหนักของแผง		83 kg/kWp (1	2 kg/m ²)			
 พลังงานไฟฟ้าที่ผลิตได้เฉลี่ยต่อ 	1 kW _p ของแผง	1,300 kWh/k	V _₽ /у (หน่วย	ต่อปี) หรือ 108 kWh/kWp/n	า (หน่วยตอเดือน)	
5. การสนับสนุน		บ้านอยู่อาศัย		อาคารธุรกิจขนาดเล็ก	อาคารธุรกิจขนาดกลาง-ใหญ่/โรงงาน	
อัตราค่าไฟฟ้า Feed In Tariff (ม	ed In Tariff (บาท/หน่วย) 6.			6.55	6.16	
ค่าไฟฟ้าที่ได้รับ (บาท/k₩₀/ปี)		9,048		8,515	8,008	
ด้วอย่าง	บ้านอยู่อาศัย		อาคา	รธุรกิจขนาดเล็ก	อาคารธุรกิจขนาดกลาง-ใหญ่/โรงงาน	
ติดดั้งระบบ Rooftop PVขนาด	5 kWp		200 k	W _p	1,000 kWp	
ใช้พื้นที่ดิดดั้งอย่างน้อยประมาณ	35 m ²		1,400	m ²	7,000 m ² (4.375 ls)	
น้ำหนักแผงรวม	414 kg		16,55	2 kg (16.5 ຕັນ)	82,759 kg (83 ตัน)	
เงินลงทุน	300,000 บาท		12,00	0,000 บาท	60,000,000 บาท	
พลังงานไฟฟ้าที่ผลิดได้ด่อปี	6,500 หนวย/ปี		260,0	00 หน่วย/ปี	1,300,000 หนวย/ปี	
รายรับจากการจำหน่ายไฟฟ้าด่อปี	45,240 บาท/ปี		1,703	,000 บาท/ปี	8,008,000 มาท/ปี	
ระยะเวลาคืนทุน (Simple Payback Period)	6 ปี 7 เดือน	7 ปี			7 ปี 6 เดือน	

Figure 4 : Default Investment Cost from Ministry of Energy of Thailand



Figure 5 : PV Type in the program can be changed (Poly, Multi –Crystalline and Thin-Film consequently)

Result

The program can add simple input parameter following in Table 1 and show the simple GUI in Figure 6, Figure 7 and Figure 8

iSolar Home Site Location Roof Detail PV and System Detail Economics Notice	×
TH EN Welcome	Area - sq.m. PV Type -
ลงทุนติดตั้งโซล่า บนหลังดาบ้าน มาหลังดาบ้าน มาไฟฟัาเชี ช่วยชาติลด มาไฟฟัาเชี ตอนกลางวับ	Total Power - Watt Total Power - Watt Total Power - Watt Total Weight - Kgi Budget - Baht Cost - Baht/Unt Saling Prior 4:12 Baht/Unt Falling Prior 4:12 Baht/Unt
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Figure 6 : Home Page of the Program





					ALL.
conomic Parameter	M (Baht/Vear) cal	ine Drive (Delati(Jaia)		Area 100.0 sq.m.	
371200 8712		2		PV Type Poly-Crystiline	
udget (Baht/Watt) O and	M (%/Budget/Year) Dis	count Rate (%)		Rower 220 Wott	1115
5 1.000	6.0	0		Fower 550 watt	
		Life	Project : 25 Years	Iotal Power 15,840.0 Watt	
at Propart Value (Raht)	Paubacknerind (Vear)	Cost per Lloit (Babt	/kW/b)	Total Weight 1,188.0 Kgs	$- \mathbf{C}$
149.091	Simple	Levelize Cost	3 347	Budget 871,200.0 Baht	
nternal Rate of Return (%)	10.1	Investment	2.942	Cost 3.3 Baht/Unit	
7.741	Discount	Operation	0.405	Selling Price 4.12 Baht/Unit	
	18.7		0.100	Pauback 10.1 Vear	<i>A</i>
				Tuybuck Io.T Icur	444
	Electric Sale Revenue I	(Baht/vear)		mm /	
	88,525.99				

Figure 8 : Economics result of the program

And testing of the program, the study compare between result of the program and general calculation and can show the simple result in Table 2.

Item	iSolar
Location	Thailand / Ban

Table 1 : Input Parameter

Item	iSolar	General Calculation			
Location	Thailand / Bangkok / Bangkuntian / Takam				
Location	(13.565	492, 100.426679)			
Install Area		15 sq.m.			
Install Tilted		15 degree			
DV Turno	Poly-Crystalline (Size: 0.992 x 1.956 m.) (Weight : 26 kgs)				
PVType	(Operate Temp : 60 C)				
Discount Rate		6.00%			
Investment	60 Baht / W	att (18.48 Yen / Watt)			
O & M	1 % of	Investment Cost			
Selling Price	4.12 Baht/k	xWh (1.27 Yen/kWh)			
Life project		25 Years			

Item	iSolar	General	Error Percentage
		Calculation	%
Global Radiation (kWh/m2/day)	5.15	5.15	0 %
Total Module (Module)	7	7	0 %
Total Power (Watt)	2,450	2,450	0 %
Energy Production (kWh/year)	3,785	3,785	0 %
Total Weight on Rooftop (kgs)	200.2	200.2	0 %
Simple Payback Period (Years)	11.6	11.6	0 %
Production Cost (Baht/kWh)	3.482	3.482	0 %
(Yen/kWh)	1.072	1.072	0 %
IRR (%)	7.243	7.243	0 %
NPV (Baht)	17,796	17,795	0.6%

Table 2 : Output Result

Conclusion

In conclusion, this study can develop and create economic analysis application for Solar Rooftop Electricity Generating in Thai Residential. And economic analysis application that easy to understand for Thai residential. This application analyzes both technical and economical, that provide people with guideline about on the cost and return of solar investment. Finally the error is less than 1% from general calculation.

Acknowledgement

I would like to express my sincere thanks to my family, my advisor (Assoc.Prof.Dr. Chatchan Thongjub, Dr.Amporn Kunchornrat and Dr.Jantana Kunchornrat) for invalueable help, advise, support and encouragement throughout the course of this research. I am most grateful for their teaching and advice, not only the research methodologies but also many other methodologies in life. I would not have achieved this far and this thesis would not have been completed without all the support that I have always received from theirs.

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A Sustainable Cement Replacement Material From a Coal-Fired Power Plant Waste

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Abstract

Electrical energy is an important in a daily life. Coal is a primary fuel for electricity production. The waste from the coal-fired electricity generation is a fly ash. The numerous fly ash is a low quality fly ash (LQFA). LQFA is a low reactivity ash, and is a hazardous waste. Normally, LQFA is stored in the landfills. The heavy metals can leach from the stored LQFA into an environment, which is a serious problem. The sustainable ways to solve the problem is to utilize LQFA as a valuable material.

Although, cement is widely used in the construction work, it is an environmental unfriendly material. The high quantities of carbon dioxide gas are emitted from the cement producing process. Geopolymer is expected to be a sustainable cement replacement material due to its manufacturing process does not emit a carbon dioxide gas. Furthermore, geopolymer can be synthesized from the various types of waste materials

The aim of this work is to develop the geopolymer by using the LQFA and a calcined clay (CC) as a precursor. The results show that the compressive strength of LQFA-CC-geopolymer is higher than that of the commercial cement. The compressive strength of LQFA-CC-geopolymer is increased with increasing the concentration of NaOH and the ratio of Na₂SiO₃ to NaOH solution. The knowledge of this work opens an opportunity to utilize the LQFA as a cement replacement material to reduce an environmental impact of the coal-fired power plant waste.

Keywords: Coal-fired electricity waste, Cement replacement, Geopolymer, Fly ash, Calcined clay

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Introduction

Portland Cement (PC) is one of the most used materials in the world. However, PC has negative environmental impacts because its production process requires high energy consumption and release a lot of carbon dioxide gas. The latter is the main cause of the global warming. Recently, several researchers have been investigating for a sustainable cement replacement material. Geopolymer is one of the most interested alternatives.

Geopolymer is an environmental friendly material, and, is expected to be used as the sustainable cement replacement materials. Because, the geopolymer production process consumes low energy and does not emit carbon dioxide gas to an environmental. Geopolymer can be synthesized by using the aluminosilicate materials mix with alkali hydroxide and/or alkali silicate. The aluminosilicate materials are the silica (SiO₂) and alumina (Al₂O₃) rich materials. Variety of aluminosilicate materials are used for synthesized geopolymer such as calcined clay (CC), fly ash, bottom ash, and water treatment sludge (Ekkasit et al., 2016).

Fly ash is the waste from the coal-fired power plant, and is mainly used as the pozzolanic materials for the building applications. However, not all of fly ashes are suitable for construction applications. The properties of fly ashes depend on the fuel nature and the furnace used (Wesche, 1991). High quality fly ash is a highly desirable commodity in the construction industry, because, it is a high reactivity ash. High quality fly ash is obtained from high quality coal (anthracite and bituminous) with high temperature (around 1100 to1700 °C) combustion system. Morphology of the high quality fly ash is mainly vitreous spherical particles. However, the numerous fly ash is the low quality fly ash (LQFA). Wesche (1991) has described that LQFA is a low reactivity ash, and, has a high percentage of irregular crystalline particles. LQFA is a hazardous waste, it is undesirable for building applications. Normally, LOFA is stored in the landfills. The heavy metals can leach from the stored LQFA into an environment, which is a serious problem. In addition, the number of LOFA trend to significantly increase year by year. The sustainable ways to solve the problem is to treat LQFA as a valuable material, that is geopolymer. Although, several researchers study on the development of geopolymer from fly ash, there are a few work reports on the development of geopolymer from LQFA.

The aim of this work is to develop a geopolymer material from LQFA blends with a calcined clay (CC). The effect of LQFA/CC ratios, concentration of sodium hydroxide (NaOH) and the ratios of sodium silicate (Na₂SiO₃) to sodium hydroxide on compressive strength of the LQFA-CC geopolymer are examined. This research will enable LQFA traditionally destined for landfills to be used in a sustainable manner as a precursor in geopolymer, which is significant from engineering and environmental point of view.

Materials and methods

Precursor preparation

The LQFA was passed through a sieve (number 120 mesh) and oven-dried at 100 °C for 24 hours to remove the impurities in the LQFA. Kaolinite clay from Ranong province, Thailand was milled by mortar and passed through a sieve (number 120 mesh) before being calcined at 600 °C for 3 hours to obtain CC powder.

Sample preparation

Sodium hydroxide (NaOH) pellets and distilled water were mixed to obtain a concentration of 5, 10 and 15 M, then allowed to cool down at a room temperature. The alkali activator solution was prepared by mixing sodium silicate (Na₂SiO₃) solution with NaOH solution. The ratios of Na₂SiO₃ to NaOH were 0:1, 0.5:1, 1:1, 1.5:1, 2:1 and 1:0 by weight. The mixed solutions were stored for 24 hours prior to use. Chemical composition of Na₂SiO₃ solution consists of Na₂O = 16.3 %, SiO₂ = 34.2 % and H₂O = 49.5 %.

LQFA and CC powder were mixed in the various LQFA/CC ratios of 100:0, 50:50, 40:60, 30:70, 0:100 by weight. The mixed powder was mixed with an alkali activator solution by a mortar at a solid to liquid ratio of 1.0. Then, the slurry mixture was poured into a 50 mm x 50 mm x 50 mm steel mold and compacted as described in ASTM C109 (2002). The samples along with the molds were sealed with vinyl sheet to prevent moisture evaporation during curing at 60 °C for 7 days.

Characterization techniques

Morphology and mineral compositions of LQFA were evaluated by scanning electron microscope (SEM, JOEL JSM-6010LV) and X-ray diffraction (XRD, Bruker D5005) with CuK_a radiation, respectively. X-ray fluorescence (XRF, HORIBA XGT-5200) was used to analyze chemical compositions of LQFA and CC. Density and compressive strength of the 7 days cured samples were measured following ASTM C138 (2009) and ASTM C109 (2002), respectively.

Results and Discussion

Chemical compositions of LQFA and CC are seen in table 1. Main chemical compositions of LQFA and CC are SiO_2 and Al_2O_3 .

		iposition	<u>, 01 LQ1</u>	II und Co	0.			
Raw	_	Chemical compositions (weight%)						
materials	Al_2O_3	SiO ₂	K ₂ O	Na ₂ O	CaO	MgO	Fe ₂ O ₃	Etc.
LQFA	19.68	33.19	2.29	2.40	11.93	4.43	10.64	15.44
CC	48.48	49.40	0.99	0.08	0.01	0.12	0.67	0.25

TT 1 1 1	C1 · 1	• , •		1.00
Table I.	Chemical	compositions	OT LQI	A and CC.

The X-ray diffractograms of LQFA is seen in Figure 1, crystalline phase of SiO_2 and $CaSO_4$ are the main compositions. Figure 2 shows SEM micrograph of LQFA. Almost all particles are irregular in shape. The XRD and SEM results demonstrate that the used fly ash is in the type of LQFA.



Figure 1 X-ray diffraction (XRD) spectra of LQFA



Figure 2 SEM image of LQFA; almost all particles are irregular in shape.

Figure 3 illustrates that by using LQFA as a precursor alone, geopolymer has low strength. Because, LQFA has low reactivity with the alkali activator solution. Compressive strength of LQFA-geopolymer is around 10 MPa, is lower than the minimum requirement for PC of 19 MPa (ASTM C150, 2003). Compressive strength of CC-geopolymer is around 34 MPa, which is higher than that of LQFA-geopolymer. Because, CC has high reactivity with the alkali activator solution (Zuhua et al., 2014). Therefore, compressive strength of LQFA-geopolymer is improved via replace LQFA by CC. The maximum strength is obtained at LQFA/CC ratio of 50:50 by weigth, and is around 42 MPa. However, strength of LQFA-CC-geopolymer is reduced when LQFA is replaced by CC over 50 wt%. The role of the LQFA/CC ratio on the developed strength is explained in the term of the Si/Al ratios. Table 2 presents Si/Al ratios for various LQFA/CC ratios, which were calculated from the chemical compositions of the LQFA and CC (Table 1), as well as the Na₂SiO₃ solution. The Si/Al ratio is an importance factor for the developed strength of geopolymer.

suitable Si/Al ratios for the cement replacement materials were reported as approximately 3 - 4 (Chindaprasirt et al., 2012 and Abdullah et al., 2011). Although, CC has high reactivity with the alkali activator solution, Si/Al ratio is reduced with increasing of CC replacement.



Weight ratio of LQFA to CC

Figure 3 compressive strength of the geopolymers with different LQFA/CC ratios; all samples used NaOH 15 M mixed with Na₂SiO₃ (Na₂SiO₃/NaOH ratio = 2:1), as the alkali activator solution.

Compositions (weight %)		Si/Al ratios	
LQFA	CC	SI/AI latios	
100	0	2.4	
50	50	1.6	
40	60	1.5	
30	70	1.4	
0	100	1.3	

Table 2. Calculation of Si/Al ration in the different replacement of LQFA by CC

Figure 4 and Figure 5 demonstrate that the high compressive strength of LQFA-CCgeopolymer is obtained by using high concentration of NaOH (Figure 4) with high Na₂SiO₃/NaOH ratios (Figure 5). In addition, figure 5 shows that both of NaOH and Na₂SiO₃ are required for obtaining the high strength LQFA-CC-geopolymer. By using NaOH or Na₂SiO₃ as the alkali activator solution alone, LQFA-CC-geopolymer has low strength. Strength of geopolymer is developed via geopolymerization process. The role of NaOH and Na₂SiO₃ in the geopolymerization process is the dissolvent and the binder, respectively. High concentration of NaOH promotes dissolution of fly ash, as well as, increases the concentration of Al³⁺ and Si⁴⁺ ions (Ubolluk and Prinya, 2009). The linkage between Al³⁺ and Si⁴⁺ ions in the geopolymerization process is enhanced by increasing amount of Na₂SiO₃ which act as a binder. By using 15 M of NaOH with Na₂SiO₃/NaOH ratio is 2:1, compressive strength of LQFA-CCgeopolymer is around 42 MPa, which is higher than the minimum requirement of PC.



Figure 4 compressive strength of the geopolymers with different concentration of NaOH. All samples have the ratio of LQFA/CC and Na₂SiO₃/NaOH is 50:50 and 1.5:1, respectively.



Figure 5 compressive strength of LQFA-CC-geopolymer with different Na₂SiO₃/NaOH ratios; the LQFA/CC ratio of 50:50 and NaOH 15 M are used for all samples.

Density of material is important for a structure cost. Density of all samples in the present work are around 1.12 to 2.18, which are lower than that of PC. The density of PC is approximately 3.15 g/cm³ (ASTM C138, 2009; ASTM C185, 2008; ASTM C595/C595M, 2013). Low density is an advantage of the LQFA-CC-geopolymer over PC, which can be used for development of the lightweight materials. The outcome of the present work opens an opportunity to utilize LQFA as the sustainable cement replacement materials.

Conclusions

In the present work, a sustainable cement replacement material was developed by using a coal-fired power plant waste, i.e., low quality fly ash (LQFA) blend with a calcined clay (CC), as the precursor. LQFA has low reactivity with the alkali activator solution. Reactivity of the precursor is enhanced by blend LQFA with CC. Strength of the LQFA-CC-geopolymer is higher than the minimum requirement of Portland cement (PC) around 2 times after curing at 60 °C for 7 days. By using NaOH or Na₂SiO₃ as the alkali activator alone, LQFA-CC-geopolymer has low strength. The high concentration of NaOH solution and the sufficiency of Na₂SiO₃ binder are required to obtain the high strength LQFA-CC-geopolymer. Density of the LQFA-CC-geopolymer is significantly lower than that of PC. The knowledge in this work opens an opportunity to convert the hazardous west to be the useful product, i.e., a sustainable cement replacement material.

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Significance of Household Composition on Electricity Consumption and Carbon Emissions

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Abstract

In one country, there are various patterns of household composition consisting of the number of member and the age of each member in the household. Additionally, the consumption patterns of member in each age range are different. Consequently, the estimation of household electricity consumption and its carbon emissions without considering on the household composition is not enough and will lead to inaccurate results. Therefore, this paper emphasizes on investigating the change of electricity consumption and carbon emissions of household when the household composition change. The Age-Oriented Linear Expenditure System and the household socioeconomic survey of the national statistical office of Thailand were utilized to econometrically estimate the household consumption model. The results of this paper expressed that household composition or the living style of people significantly caused different electricity consumption and carbon emissions. Living together with other family members or friends in the same household was the alternative way to reduce the aggregate electricity consumption and mitigate the aggregate carbon emission of the whole country. The government may apply the results on the energy and environmental policy relating to the population demographic change.

Keywords: household composition, electricity, consumption, carbon emissions

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1. Introduction

The National Statistical Office (NSO) has begun to do reports on household energy consumption since the year 1995. The household in the urban area consumed the energy commodities higher than that the household in the rural area. The average household expenditure on energy was about 10% of total household expenditure. About 60% of energy consumption was for gasoline and liquid petroleum gas (LPG) commodities, while about 30% of energy consumption was for the electricity. The trend of household consumption on electricity and cooking gas has increased every year, while the trend of household consumption on charcoal and fire wood has decreased continuously. Most of consumption on charcoal and fire wood are that of the household in rural area. Thai household has tended to use the alternative energy or the renewable energy more and more in the future.

Regarding to the Input-Output table of Thailand in the year 2010, it showed that the direct consumption or the final demand on electricity of the household sector was about 103,381.4 Million Baht or about 14.45% of the aggregate electricity consumption of the whole country. Energy Research Institute (2000) analyzed the demand for energy of Thailand during the year 1995 - 2000 and forecasted the demand for energy of Thailand in the future during the year 2002 - 2025. The study found that the demand for energy of Thailand will increase around 2 times from 48.74 Mtoe in the year 1995 to 158.87 Mtoe in the year 2025. While demand for energy of the household sector will increase around 1 time from 10.3 Mtoe in the year 1995 to 19.75 Mtoe in the year 2025. The household consumption on electricity and cooking gas will increase around 0.63 time and 1.22 time respectively in the year 2025 comparing with that of in the year 1995. It reflected that Thailand tended to face the problem of energy shortage in the coming future.

Gamtessa (2003) studied the demand and consumption pattern in the urban area of Ethiopia. He found that 92.83% of household used the electricity as the primary household energy and 70.99% of household used the kerosene as the household energy. The interesting found was that there was up to 67.95% and 57.48% of Ethiopia household used the charcoal and fire wood respectively, while there was only 1.86% of household used cooking gas. He also found that the household expenditure share on electricity decreased when the household income increased. The low income household had the household expenditure share on electricity at 17.6%, while the high income household had the household expenditure share on electricity at 9.3%.

Stone (1954) proposed the famous household consumption model named Linear Expenditure System (LES) which explain the relationship of household consumption behavior to commodity prices and household budget. He assumed that all household consumers want to maximize their happiness by utilizing their limited budget. However there were many economists tried to fulfill the weakness of the LES model by adding other significance factors in the model.

Howe (1977) added some sociodemographic variable into the subsistence quantity variable term of the original LES model. He classified the member age into 3 age groups i.e. 0-7 years old, 8-17 years old, and over 17 years old. Nevertheless, he emphasized on the member who are younger than 17 years old, while the member

who are older than 17 years old was categorized into only one group. Pollak and Wales (1981) utilized the generalized Constant Elasticity of Substitution (CES) demand system to analyze the household behavior with demographic variables. Unfortunately, they still focused only on the number of children in household but not interested in the member age. Derrick and Wolken (1982) investigated the difference of estimated results of the household demand system between the pooled household data and the unpooled household data. They applied some dummy variables into subsistence quantity variable term of the original LES model. The disadvantage of their model was that their model cannot differentiate the impacts of number of member in each age because their dummy variables are not the quantitative variable.

Chomtohsuwan (2010) tried to investigate the difference in consumption pattern of each member age group by separating the household data into four member age group and applying the original LES model to each member age group. He found that the committed consumption level and marginal expenditure of each member age group were significantly different. It showed that the data separation was the one of method which can solve some weakness of the original LES model. The consumption patterns of member in each age range are different. Nevertheless, the data separation method was still not enough to represent the complex behavior of the household which there were various member age living together in the same house. Chomtohsuwan (2012) developed the household consumption model named the Age-Oriented Linear Expenditure System (ALES) by modified the committed consumption level and marginal expenditure coefficients of the original LES model with the household composition coefficients and variables. The ALES model was able to well explain the difference and significance of the change of household consumption.

Because of the various patterns of household composition and the various member ages. Although each households has the same number of member but the different member age, the pattern of consumption of each household is also different. Consequently the estimation of household consumption and carbon emissions need to consider the household composition factor. Therefore, this paper aim to investigate the effect of change in household composition on the household electricity consumption and carbon emission by utilizing the ALES model. The results of this paper can be applied to estimate the more accurate electricity supply for supporting the household sector in the future especially in coming aged society. It also can be the tool for population policy planer to develop the population and household policies which help to solve the problem of energy shortage and climate change.

2. Methodology

The study investigated the household characteristic and consumption behavior by utilizing the two main secondary data of the year 2010 i.e. the household socioeconomics survey data collected by the National Statistical Office and the retail price of commodities survey collected by Ministry of Commerce. To simplify the model, the study classified the member age into 4 age groups i.e. Young age group which covered the member who was between 0 and 19 years old, Adult age group which covered the member who was between 40 and 59 years old, and Old age group which covered the member who was older than 60 years old. The commodities were categorized into 4 commodity groups i.e. Food commodity group, Electricity commodity group, Cooking gas commodity group, and Other nonfood commodity group.

The study applied the Age-Oriented Linear Expenditure System (ALES) model developed by Chomtohsuwan (2012) to represent the household consumption behavior, as shown in Equation 1 to Equation 3.

$$E_{i} = P_{i} \left[\overline{\gamma}_{i} + \sum_{a=1}^{m} \widetilde{\gamma}_{i}^{a} N^{a} \right] + \left(\overline{\beta}_{i} + \sum_{a=1}^{m} \widetilde{\beta}_{i}^{a} N^{a} \right) \left[E_{i} - \sum_{j=1}^{n} P_{j} \left(\overline{\gamma}_{j} + \sum_{a=1}^{m} \widetilde{\gamma}_{j}^{a} N^{a} \right) \right] \qquad \dots (1)$$

$$E_i = P_i Q_i \qquad \dots (2)$$

$$E = \sum_{i=1}^{n} E_i \qquad \dots (3)$$

Where *E* is the expenditure on a commodity, *i* and *j* is the subscript of each commodity group, *P* is the commodity price, *Q* is the consumption level on a commodity, $\overline{\gamma}$ is the common committed consumption level which $\overline{\gamma} \ge 0$, $\widetilde{\gamma}$ is the additional committed consumption level of each member which $\widetilde{\gamma} \ge 0$, *a* is the superscript of each member age group, *N* is the number of household members which $N = \sum N^a$ and $0 < \overline{\gamma} + \sum \widetilde{\gamma}^a N^a < Q$, $\overline{\beta}$ is the common marginal expenditure which $\overline{\beta_i} \ge 0$ and $\sum \overline{\beta_i} = 1$, $\widetilde{\beta}$ is the additional marginal expenditure of each member age on the change of the household marginal expenditure which $\sum \widetilde{\beta_i} = 0$.

The relative price index was applied to estimate the representative price of each commodity group in each region for solving the obstacles about the differences in the commodity unit of each commodity in the same commodity group, as shown in Equation 4. This study separated household location into 4 regions i.e. Bangkok, East, North, Northeast, and South. Bangkok was defined to be the reference region.

$$\vec{P}_{ir} = \sum_{k=1}^{n} \left(\frac{P_{kr}}{P_{kx}} \right) \omega_{kr} \qquad \dots (4)$$

Where \ddot{P} is the relative price index, P is the commodity price, i is the subscript of each commodity group, r is the subscription of each region, k is the subscription of each commodity in the commodity group i. x is the subscription of the reference region, ω is the expenditure share of a commodity.

The study developed the regression model to estimate the total household expenditure which varies on number of household member in each member age group to be representative total household expenditure of each household composition scenario, as shown in Equation 4.

$$\vec{E} = \delta + \sum_{a=1}^{m} \left[\alpha^{a} N^{a} \right] \qquad \dots (5)$$

Where \vec{E} is the total household expenditure, δ is the common household expenditure level, α is the additional household expenditure level of each member, a is the superscript of each member age group, N is the number of the household members which $N = \sum N^a$.

Carbon emission of Greenhouse gas (GHG) was estimated by applying the formula and parameters from Thailand Greenhouse Gas Management Organization (TGO) as shown in Equation 6. Where ε is the greenhouse gas emission of a commodity in CO2e unit, Q is the consumption level of a commodity, λ is the greenhouse gas emission factor of a commodity, μ is the global warming potential of greenhouse gas.

$$\varepsilon_i = Q_i \sum_{g=1}^h \left[\lambda_i^g \,\mu_i^g \right] \qquad \dots (6)$$

The study evaluated the impact of change in household composition on electricity consumption and carbon emissions by estimating the electricity expenditure of each household composition scenario and comparing the results with the base scenario. There were four scenarios in this study. Scenario I was the Representative household scenario or Base scenario which was used to estimate the aggregate household consumption by managing the household composition of every household to be the average household composition. Scenario II was the Single household scenario which was used to estimate the aggregate household consumption by managing the household composition of every household to be the one member household. Scenario III was the None alone household scenario which was used to estimate the aggregate household consumption by managing the household composition of the single household to be the two member household. These new households of Scenario II were the households of the two members who have the same age group. Scenario IV was the Four generation household scenario which was used to estimate the aggregate household consumption by managing the household composition of every household to have eight members from every age group. The population constraint of these scenarios was every household compositions of four scenarios were managed based on the same population demographic of the whole country. In other words, the aggregate populations of each age group are same in every scenario.

3. Results

The study analyzed 44,273 samples of the household socio-economics survey and over 500 commodities of the retail price of commodities survey. The results were as follows.

3.1 Household characteristics

In the year 2010, there were around 19.74 million households in Thailand. The average household size was 3.23 members per household. Most household sizes were 2 members, 3 members, and 4 members at 24.99%, 23.15%, and 18.98% of total household respectively. There was 15.27% of total household which had only 1 member. The average household expenditure was 15,407.71 Baht per month. The household expenditure tended to be higher when the household size was bigger. It should be noted that the household consumption behavior of the household which was bigger than 12 members was high volatility, as shown in the Figure 1.



Figure 1: Distribution of household size and its monthly expenditure

The small household had the high proportion of Adult age member, Middle age member, and Old age member. The most members of the single household were Middle age member, while the Young age members rarely lived alone. The big household had the high proportion of the Young age member and the low proportion of Old age member. The representative household had Young age member, Adult age member, Middle age member, and Old age member about 27.58%, 25.65%, 31.01%, and 15.76% respectively, as shown in the Figure 2.



Figure 2: Percentage share of member age in each household size

The average household expenditure on the Food commodity group was 5,528.49 Baht per month or 35.88% of total household expenditure. The average household expenditure on the Electricity commodity group was 535.05 Baht per month or 3.47% of total household expenditure. The average household expenditure on the Cooking gas commodity group was 67.05 Baht per month or 0.44% of total household expenditure. The average household expenditure on the Cooking group was 9,277.12 Baht per month or 60.21% of total household expenditure. The household expenditure on every commodity group tended to be higher when the total household expenditure was higher, as shown in the Figure 3.



Figure 3: Relationship between commodity consumption and total household expenditure

Nevertheless the determiners of household consumption were not only the commodity prices and the household income but also the member age and the number of member in the household which were quite hard to explain. Therefore this study utilized the mathematical model to learn about the household consumption behavior which varied on the change of the household composition, as described in the next section.

3.2 Household consumption patterns

The relative price index results showed that the prices of electricity in every region were same. The price of Food commodity group in South region was higher than that in other regions. The price of Cooking gas commodity group in Bangkok was lower than that in other regions but the price of Other nonfood commodity group was higher than that in other regions, as in the Figure 4.



Figure 4: Relative price index of each commodity group

In the Table 1, the estimated coefficients of the ALES model implied that the committed consumption of the member in Young age group was lowest and continually increased when the member age increased. The committed consumption was highest when the member age was in Middle age group and then slightly decreased when the member age was in the Old age group.

When the household income increased, the Young age member increased consumption on Other nonfood commodity at the highest proportion, followed with Food commodity, Electricity commodity, and Cooking gas commodity respectively. Adult age member and Middle age member increased consumption on Other nonfood commodity at the highest proportion, followed with Electricity commodity, Cooking gas commodity, and Food commodity respectively. Old age member increase consumption on Electricity at the highest proportion, followed with Other nonfood commodity, Cooking gas commodity, and Food commodity at the highest proportion, followed with Other nonfood commodity, Cooking gas commodity, and Food commodity respectively.

Coefficient		Commodity Group					
		Food	Electricity	Cooking Gas	Other Nonfood		
	Common	523.5520	60.0033	9.0147	341.6267		
Committed	Young age	352.5318	9.1695	3.3167	70.8489		
consumption level (γ)	Adult age	1186.1540	53.2654	14.5482	168.1790		
	Middle age	1302.4740	88.9511	21.5743	180.2750		
	Old age	856.7273	61.9250	14.3089	145.5643		
	Common	0.192426	0.019513	0.000463	0.787598		
Marginal	Young age	0.015480	0.001538	0.000519	-0.017537		
expenditure	Adult age	-0.006458	0.001402	-0.000041	0.005097		
(β)	Middle age	-0.021204	0.001835	0.000204	0.019165		
	Old age	-0.009868	0.005462	0.000662	0.003744		

 Table 1: Estimated coefficients of the ALES model

The interesting found was the member in Old age group had the highest marginal expenditure on Electricity and Cooking gas. While Young age member had the highest marginal expenditure on Food commodity and Middle age member had the highest marginal expenditure on Other nonfood commodity. Most estimated coefficients in the model had the significance level of 0.01. R-square value of the Food equation, Electricity equation, and Other nonfood equation were 0.5747, 0.3869, and 0.9517 respectively.

δ	α			
	Young	Adult	Middle	Old
	age	age	age	age
6476.507	745.052	4112.103	4179.085	1521.364

 Table 2: Estimated coefficient of the total household expenditure model

In the Table 2, the estimated coefficients of the total household expenditure model implied that the Young age member had the lowest impact on household expenditure. The Middle age member had the highest impact on household expenditure, followed with the Adult age member and Old age member respectively. All estimated coefficients in the model had the significance level of 0.01. The R-square value of the model was 0.1225.

3.3 Significance of household composition

The Table 3 revealed the impacts of change in household composition. In the Scenario I or Representative household scenario which was the Business as usual (BAU) case, the annual aggregate household consumption on electricity commodity was 10,419.08 million baht per year. When the every people changed their living style to living alone as Scenario II or Single household scenario, the annual aggregate household consumption on electricity commodity increased to be 17,300.57 million
baht per year. It reflected that when the trend of living alone increased the problems of world energy shortage and carbon emissions were more intense.

Unit: Million baht pe						
Commodity Group	Scenario I Representative Household	Scenario II Single Household	Scenario III None Alone Household	Scenario IV Four Generation Household		
Food	106,917.72	177,528.38	101,999.28	85,355.90		
Electricity	10,419.08	17,300.57	10,037.02	9,562.00		
Cooking Gas	1,387.87	1,821.18	1,350.28	1,402.30		
Other Nonfood	187,375.10	394,546.77	176,897.15	133,551.25		
Total	306,099.76	591,196.90	290,283.73	229,871.44		

Table 3: Estimated annual aggregate expenditure of the all households

On the other hand, when we were able to motivate the people who were living alone to change their living style to live together with another one person who was also living alone and was in the same age group. Consequently the single household in the Scenario I became the couple household as Scenario III or None alone household scenario. It reduced the aggregate household consumption on electricity commodity to be 10,037.02 million baht per year. Moreover when we were able to motivate every people to change their living style to live with their family or warm family household which children, mother, father, grandfather, and grandmother lived together in the same household as Scenario IV or Four generation household scenario. It was able to reduce the aggregate household consumption on electricity commodity to be 9,562.00 million baht per year.



Figure 5: Electricity consumption and Carbon emission by scenario

The effects of household composition change as the results in Figure 5 expressed that the Scenario I or Representative household scenario (BAU scenario) consumed the electricity about 3,028.73 Gwh and emitted the Greenhouse Gas (GHG) about 1,699.12 GgCO2e. The Scenario II or Single household scenario was the worst case of this study that consumed the electricity about 5,029.12 Gwh and emitted the GHG about 2,821.33 GgCO2e which increased by 66.05% comparing with the BAU scenario. The Scenario III or None alone household scenario consumed the electricity about 2,917.67 Gwh and emitted the GHG about 1,636.81 GgCO2e which decreased by 3.67% comparing with the BAU scenario. While the Scenario IV or Four generation household scenario was the best case of this study that consumed the electricity about 2,779.59 Gwh and emitted the GHG about 1,559.35 GgCO2e which was able to decrease up to 8.23% comparing with the BAU scenario.

4. Concluding remark

This study points the qualitative and quantitative significances of household composition consisting of the member age and the number of member. The living style of people cause different electricity consumption and different carbon emissions. Living together with other family members or friends in the same house will help to reduce the aggregate electricity consumption and mitigate the aggregate carbon emissions of the whole country.

Therefore, the way to solve the problem of energy shortage and climate change in the future is not only investigating the new energy resources, supporting the green energies, promoting the green technologies but also encouraging the world population

to reverse their living style from living alone to become living together especially the family members live in the same house.

Author hopes that this research would spark the government sector and the nongovernmental organization (NGO) to do research and development not only on the digital and mechanical technology but also the human and social technology. It is because sometimes the human and social technology may be able to solve the hard problems of this planet better than the digital and mechanical technology.

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Synthesized Silica from Rice Husk for Anti-slip Overprint Coating

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Abstract

Thailand is among the top ten rice exporters that have produced more than 30 million tons of rice in order to serve domestic and worldwide consumption. In a process of rice milling, more than 10 million tons of rice husk as agricultural waste are disposed. Since rice husk is enriched with abundant silica (SiO₂), this study aims to reflux silica from rice husk by 2M hydrochloric acid (HCl) for 120 min. The results yielded refluxed silica whose purity was 98.7% and had an amorphous structure. The silica powder was measured the color by a spectrophotometer according to printing standard (ISO12647-1), the color measurement (CIE L*a*b*) indicated 94.79+0.48+1.24 (white color), whiteness and color difference (ΔE) were 84.85, 3.28, respectively. Particle size of silica was analyzed by "Image Plus Pro" and exhibited a uniform size of 3-5 µm. The synthesized silica from rice husk was used as a anti-slip coating material for the improvement friction and smoothness on white kraft papers. The coating was prepared by a water-based varnish of acrylic resin mixed with the synthesized silica from rice husk at different ratios of 0%, 0.5%, 1.0%, and 1.5% on the weight basis. The varnished with 1.0% silica from rice husk displayed the highest friction and printing quality wasn't changed.

Keywords: Rice husk/Silica/Anti-slip/Overprint varnished

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Introduction

Nowadays, Thailand is the top ten rice producer in the world. In 2016, 28 million tons of rice was produced for domestic consumption and worldwide export. Consequently, rice milling process disposed approximately 9 million tons rice husk as agricultural waste (Agricultural statistics, 2016). However, rice husk can be used as heating fuel in the production of bricks and electicity. It is also utilized for animal feed and fertilization. Due to energy crisis, rice husk is also made for biomass in combustion process for electricity generation and heating boiler in industries. However, burning rice husk causes air pollution such as CO₂, acid rain and greenhouse effect. So, alternative methods for rice husk ash removal have been continuously studied. Generally, rice husk consists of 30% by weight of silica. After acid extraction, silica content increases up to 95% by weight (Chiarakorn S., 2003). So, rice husk and rice husk ash can be used as a natural silica source to synthesize silicate materials such as zeolite and MCM–41 (Zhao, *et al*, 1996).

About 90% paper packaging were coated with overprint varnish. Anti-slip Overprint Coating is the most offten use for coating on package, which it's made from resin mixed silica (E.W. Flick, 1999). The silica in coating is served to increase friction on paper surface (A.A. Tracton, 2005) Anti-slip properties are important for packaging in packing and transport process. This research aimed to get silica as a raw material from agricultural waste to produce Anti-slip Overprint Coating.

Experimental

Rice husks by product from rice milling in Pathum Thani Province, Thailand was used in this research. They were washed with distilled water to remove soils and dirt before drying in the oven at 105 °C for 24 h. The dried rice husks were treated chemically by a solution of hydrochloric acid (HCl) that was previously prepared at different concentrations of 1, 2, and 3 M. The rice husks were mixed with different molarities of HCl and boiled in a hood at reaction temperature of 80+5 °C at difference time for 60 and 120 min (Yalcin, N., and Sevinc, V., 2001). The solution was filtered and the rice husks were washed with distilled water several times until they were acid-free. The acid-leached rice husks were dried in an oven heat at 105 °C. They were roasted at 650–700 °C in furnaces for 240 min (Chiarakorn S., 2003). The characteristics of the obtained silica powder were then measured. Analysis of their characteristics were performed by means of X-ray fluorescence (XRF), X-ray diffraction (XRD), scanning electron microscope (SEM), particle size, color and color difference (ISO 12647-1/TIS2260-1, (2004). Selective silica powder with suitable properties in color and particle size (A.A. Tracton, 2005) was then used for Anti-slip Overprint Coating.

Varnished coating (Lloyd M. Smith, 1994) was made from 60% acrylic resin mixed with synthesized silica that had suitable properties at different ratio 0%, 0.5%, 1%, 1.5% and had additive that containing of anti-foam/wax/leveling agent at 2:3:5 in quantity of 1% and added water until got 100%. Analyzing properties of coated varnish on white kraft papers by printed test form 4 colors (Anthony P.Stanton, 1988) through inkjet printing at resolution of 4,800 dpi \times 1,200 dpi for test transparency by trans-densitometer (N. Tipsotnaiyana, *et al*, 2012) and test coefficient of friction by slip-meter (George Wypych, 2005).

Results and Discussion

Analysis purities and organic elements of Rice Husk silica

The amounts of ingredients present in the ash at various concentration of HCl and times are shown in figure 1. All the ash samples contain Silicon dioxide, Potassium oxide, Calcium oxide, Phosphorus pentoxide, Aluminums oxide and Iron (III) oxide; of which the concentration of Silicon dioxide is greatest. The impurity content is significantly reduced by the acid-leached and thermal decomposition process (Yalcin, N., and Sevinc, V., 2001). The resulting purity of silica (Silicon dioxide) is better than 98% after burning the rice husk.



Figure 1: The purity of Rice Husk silica was determined by XRF techniques

Analysis of physical properties

In figure 2 shows X-ray diffraction analysis of rice husk at various concentration of HCl and times. All samples are amorphous. However, in the ash samples (fig. 2, A–G), the typical silica characteristic was observed at a broad peak centered at $2\theta = 22^{\circ}$.



Figure 2: X-ray diffractogram of rice husk.



Figure 3: Scanning electron micrographs of rice husk: (1,000X @ 132 μm); (A) Blank; (B) 1M 60 min; (C) 1M 120 min; (D) 2M 60 min; (E) 2M 120 min; (F) 3M 60 min; (G) 3M 120 min

In figure 3 shows SEM micrographs 1,000X @ 132 μ m of rice husk silica that made from rice husk calcined in a muffle furnace at 650 °C for 240 min. fig. (A-G) shows the inner epidermis of rice husk silica, which has a lamella structure. The morphology og all figure weren't different but figure 3A showed that the surface of ground rice husk silica powder was covered with flakes. Figure 3B, 3C and 3D shows that a less pores were distributed in silica powder. Fig. 3E, 3F and 3G that the silica is a highly porous material with a large internal surface area. The particle size of silica was analyzed by "Image Plus Pro" and exhibited a uniform size of 3-5 μ m.

Analysis Optical properties of Rice Husk silica

The CIE and Delta E (Δ E, Color difference.) of Rice Husk silica powder was determined by color measurement techniques were shown in Table 1. Raw material that is suitable for producing anti-slip coating should have high whiteness and color which are similar to standards of white kraft paper (ISO 12647-1/TIS2260-1, 2004). Silica powder was made from refluxing of rice husk with HCl 2 M 120 min has a minimum Delta E = 3.28 and has maximum whiteness = 84.85

Sample	CIE L**	CIE a**	CIE b**	Delta E (ISO 12647)	Whiteness*
White paper	95.00	0.00	-2.00	-	80.00 ± 5
Blank	85.42	+3.90	+1.71	10.99	39.28
1M 60 min	94.48	+0.46	+1.39	3.46	80.17
1M 120 min	93.78	+0.45	+1.31	3.55	80.27
2M 60 min	94.54	+0.49	+1.47	3.53	80.27
2M 120 min	94.79	+0.48	+1.24	3.28	84.85
3M 60 min	93.24	+0.73	+2.08	4.51	79.00
3M 120 min	94.47	+0.39	+1.24	3.31	83.88

Table 1 Color CIE, Delta E and Whiteness of Rice Husk silica.

** Color CIE = color spaces of International Commission on

Illumination

Analyze properties and printing quality of anti-slip coating on white kraft paper (printed-test chart 4 Colors).

Varnished coating were made from acrylic resin mixed with a highest purity synthesized silica that refluxing by HCl 2 M 120 min at different ratio and the additives type anti foaming, wax and leveling agent. The coefficient of friction and transparency of coating were shown in Table 2. The friction of anti-slip coating was increased when the ratio of synthesized silica was increased from about 0.11 to 0.58. When measured transparency of anti-slip coating found that it was decreased because density of dried-layer coating was increased from 0.10 to 0.70 respectively.

Sample	Coefficient of friction : (COF)	Transparency : Density	
Coating : silica 0.0 %	0.11 ± 0.02	0.10	
Coating : silica 0.5 %	0.25 ± 0.08	0.19	
Coating : silica 1.0 %	0.44 ± 0.03	0.21	
Coating : silica 1.5 %	0.58 ± 0.05	0.70	

Table 2 The viscosity and transparency of water base coating.

After coated anti-slip coating on picture and test form that printed through inkjet printer (Canon Pixma 3000: 4,800 dpi x 1,200 dpi) on white Kraft paper. The printing quality was measured by spectrophotometer and analyze picture and color gamut of printing that were shown in figure 4-5.



Figure 4: Picture after coated anti-slip coating



Figure 5: Color gamut of printing after (silica 0%, 0.5%, 1.0% & 1.5%) coated anti-slip coating (silica 0%, 0.5%, 1.0% & 1.5%)

From Figure 4 the picture that coated by anti-slip coating containing synthesized silica 1.5% is the highest density but picture has low details in shadows tone. The printing that coated anti-slip with synthesized silica 1.0% have color density close to the synthesized silica 0.5% but detail in shadows tone is better. Figure 5 showed the color gamut of printing that coated anti-slip containing synthesized silica 0%, 0.5%,

1.0% and 1.5%. The anti-slip mixed with silica coating 1.0% have a color gamut wider scope than color gamut of printing coated anti-slip silica coating 0.0%, 0.5% and 1.5%, respectively.

Conclusions

Silica particles can be obtained from the hydrolysis reaction of silicon alkoxide. The resulting particle size and morphology depended strongly on the hydrolysis condition and reaction time. The reaction continues until the solution is super saturated. To investigate a possibility of tailoring the particle size and the particle size distribution, the X-ray diffraction indicated that the silica particles were amorphous, according to the broad peak centered at $2\Theta = 22^{\circ}$. This demonstrated that the particles had a higher percentage of amorphous than crystalline structures. The effect of different molar ratios of acidic reagents on the structure and morphology of silica particles was observed. The impurity content was significantly reduced by the acid-leached and thermal decomposition process. The resulting purity of silica was greater than 98%. The silica powder was made by refluxing the rice husk with 2-M HCl for 120 min, that was a suitable condition for raw material to produce Anti-slip coating.

The anti-slip coatings that made from acrylic resin mixed with synthesized silica 2 M HCl for 120 min in ratios is not over 1.0% have a similar transparency. Silica had ratios more than 1.0% were precipitated and reduce transparency. When coated more synthesized silica on top the printing was impact to detail and tone of picture. The coating that mixed synthesized silica from rice husk 1.0% is suitable for produce an anti-slip coating because it provided a high detail in print quality especially in shadow tone with wider color gamut.

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The Implications of Scenarios for Phosphorus Flow from Agriculture and Domestic Wastewater in Myanmar

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Abstract

The transfer of nutrients from agriculture (farmland and livestock) and wastewater to the hydrosphere invites the attention of policymakers and scientists because it constitutes an increasingly important factor influencing the water environment. Agriculture, livestock, and fisheries can be regarded as the backbones supporting the Myanmar economy. However, phosphorus (P) used for cultivation and domestic sewage is a major source of organic pollutants and eutrophication in Myanmar coastal waters. It is therefore necessary to elucidate the P flow mainly from agricultural and domestic wastewater to formulate a series of cost-effective policies and best management practices (BMPs). This paper describes P flow to the hydrosphere driven by agricultural and domestic wastewater in Myanmar during 2010-2100. Results reveal that total P flows from farmland and livestock occurred at an annual rate of 55 ktpa (thousand tonnes per annum) in 2010, but they are expected to be 128-141 ktpa in 2100. Moreover, estimated P flows from domestic wastewater are 13 ktpa in 2010 and 20 ktpa in 2100. Urban population growth is a main factor contributing to the gradual increase in P flow from domestic wastewater but most of the P flow derives from agriculture, which indicates that marked reduction of fertilizer use is necessary. Recovery of P from sewage sludge can substitute for a small share of fertilizer use. This research provides a core for the appraisal of P utilization and facilitates determination of important objectives for sustainable P management in Myanmar.

Keywords: Sustainable phosphorus management, phosphorus ore depletion, agricultural pollution, fertilizer, sewage

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Introduction

The phenomenal population increase, changes in lifestyle (improved diet and use of phosphorus detergents), and housing (increased household connection to sewage system) in Myanmar, along with the acceleration of urbanization and industry, have drastically raised the urban point release of phosphorus (P) to surface waterbodies. Moreover, agricultural intensification and the widening use of chemicals have dramatically increased P diffuse sources. Varieties of point source and non-point source pollutions transferred from terrestrial to aquatic ecosystems have contributed to the development of eutrophication in surface waters worldwide (De Jonge et al. 2002, EEA 2005).

In 2019, over 50% of all demanded phosphate fertilizer around the world was applied in Asia; roughly half of that 50% was used in eastern Asia, including all ASEAN countries and China (FAO, 2016). The rising demand for fertilizer has arisen from the need to meet the nutritional demands of the region's rapidly increasing human population. The rise in intensive fertilizer use presents severe implications for coastal habitats because greater application results in greater runoff; the fraction of fertilizer lost from fields will increase with the intensity of fertilizer application. Phosphorus (P) fertilizer use for agricultural activities has increased to meet growing demands for feeding of the world's growing population, which has also increased inflows of water containing phosphorous into the hydrosphere. Researchers around the world have conducted material or substance flow analyses of P on a global scale and on the individual country level for the past and current target timing (Chen et al. 2016, Cordell et al. 2009, Ma et al. 2013). Lwin et al. (2016, 2017) also examined global P flows, but Myanmar was not included in their research scope. This study specifically examined Myanmar to forecast P flow from agricultural and domestic wastewater during 2010–2100.

Myanmar has the fifth largest population in ASEAN and the second largest land mass. Recently, Myanmar opened up as a country after many years of military and Junta rule. It is currently embracing democracy. Located among India, Thailand, and China, it has ready access to major Indian shipping routes. Of its people, 70% reside in rural areas; most are engaged in farming. Therefore, it is often said that now is the right time to invest in Myanmar agriculture and that Myanmar is the final frontier in Southeast Asia. In Myanmar, it is estimated that the agricultural sector shares 37.8 percent of the gross domestic product (GDP) and that it accounts for 25-30 percent of all export earnings. Myanmar has an open competitive fertilizer market that is dependent on imports for over 80% of its total market demand, estimated at between 1.2 and 1.4 million product tons per annum. The fertilizer market, which is dominated by urea use, relies mainly on imports from China, entering mainly through Muse in Shan State. However, fertilizer use by farmers is insufficient for optimum yields. Farmers generally have little knowledge of the best agricultural practices and plant nutrition requirements. Consequently, large amounts of nutrients run off from agricultural land to the hydrosphere, causing eutrophication. Lack of research has left flow amounts unknown and has hindered awareness of the issue, but the effects are severe.

In Myanmar, the fishery and livestock sectors are regarded as the most important, after agriculture, to meet the protein needs of the population, to enhance food security,

and to provide employment for rural communities. The livestock and fisheries sectors account for more than seven percent of the national GDP. Regarding livestock, increased urban population plays an active role in greater livestock demand. Consequently, increased P flow from increased demand of livestock affects society and the hydrosphere, exacerbating environmental pollution of many types.

As an additional research area, P flow from domestic wastewater is estimated in this study. Myanmar has been facing considerable challenges with the management of wastewater as a result of increasing income, increasing consumption level and changing consumption patterns, urban population growth, and lack of effective wastewater treatment and disposal options. Inadequate wastewater and sanitation services combined with underinvestment in preventive health care, have presented environmental and human health challenges in Myanmar. Although Yangon, Mandalay, and Nay Pyi Taw have urban sanitation services that are well below acceptable levels, the situation is worse in other poor regions and areas of the country. With the exception of central business districts, the three major cities have no conventional central wastewater or sewerage collection and treatment systems. Domestic wastewater is usually released into storm water drainage and natural waterways. Nevertheless, environmental impact assessments do not emphasize water resource management. Because of ongoing rapid industrialization in cities, many factories are being built around urbanized areas. The need persists to disseminate knowledge about the proper disposal of wastewater to control the problems of the direct discharge of wastewater from factories into rivers or streams. Therefore, necessary and emergency estimation of P flow to the hydrosphere is necessary while introducing new wastewater treatment plants and modifying old wastewater treatment plants in Myanmar.

By quantifying amounts of P flow to the hydrosphere, this study specifically examines P in the agricultural and domestic wastewater and their environmental effects to facilitate relevant policy making. Following are the specific objectives.

- (1) To calculate the amount of P release from agricultural and domestic wastewater into bodies of water
- (2) To estimate the relative effects of efficient and less-efficient fertilizer use and sewage systems on the flow of P to the hydrosphere.
- (3) To assess possibilities for P recovery.

Methods and Data



Figure 1: Simplified flows of P from agriculture and human sewage to hydrosphere.

Figure 1 presents our P flow research scope. Flows and systems enclosed in dotted lines were excluded from our research: our system boundary includes P flow from agriculture (fertilizer and livestock manure) and domestic wastewater (excrement and gray water) for 2010–2100.

The annual P flow derived from farmland (PF_f) to water bodies is calculable using the following equation

(1).

$$PF_{f} = (\sum_{i} (P_{CROPi} \times HA_{i}) + (P_{ls} \times R_{ls}) + (P_{e} \times R_{e})) \times R$$

Eq. (1)

The P flows from livestock manure (PF_m) (tonnes/year) were calculated using equations (2)–(3).

$$PF_m = P_{ls} \times (1 - R_{ls}) \times R$$

Eq. (2)

$$P_{ls} = \sum_{i} (N_i \times P_{ANIMALi})$$

Eq. (3)

In those equations, P_{ls} signifies the P flow from livestock manure (tonnes/year), R_{ls} denotes a ratio of P return to farm from livestock manure (–), R represents the ratio of outflow to water from farm (–), N_i stands for the number of livestock animals i (beef cattle, dairy cattle, pig, layer chicken, and broiler chickens), and $P_{ANIMALi}$ represents the P content in manure of animal i per animal (tonnes/animal/year).

The P flow from human excrement (PF_e) (tonnes/year) was estimated using equations (4)–(7).

$$P_e = Pop \times P_{person,e}$$

Eq. (4)

Therein, P_e is the P amount in excrement (tonnes/year), Pop denotes population (persons), $P_{person,e}$ signifies per-capita P contained in excrement (tonnes/person/year). $PF_{e1} = P_e \times SC \times (1 - PR)$ Eq. (5)

In that equation, PF_{e1} represents P flow from excrement passing through sever treatment facilities (STF) (tonnes/year), SC is the ratio of urban population with access to STF (-), and PR represents the average P removal ratio in STF (-).)

$$PF_{e2} = P_e \times (1 - R_e) \times (1 - SC)$$

Eq. (6)

In that equation, PF_{e2} stands for the P flow from excrement without passage through STF (tonnes/year), R_e is the ratio of P in excrement returned to farmland (–).

$$PF_e = PF_{e1} + PF_{e2}$$

Eq. (7)

The P flow from gray water (PFg) (tonnes/year) was calculated using the following equations (8)–(11).

$$P_g = Pop \times P_{person,g}$$

Eq. (8)

Therein, $P_{\text{person,g}}$ denotes the per-capita P contained in domestic gray water (tonnes/person/year).

$$PF_{g1} = P_g \times SC \times (1 - PR)$$

Eq. (9)

In that equation, PF_{gl} represents the P flow from gray water passing through STF (tonnes/year).

$$PF_{g2} = P_g \times (1 - SC)$$

Eq. (10)

Therein, PF_{g2} is the P flow from gray water without passing through STF (tonnes/year).

 $PF_{q} = PF_{q1} + PF_{q2}$

Eq. (11)

As one ultimate scenario, the degree to which P can be recovered from domestic wastewater system and reused as fertilizer can be calculated using the following equation (12):

$$P_{rec} = (Pe + Pg) \times SC \times PR$$

Eq. (12)

The following are some necessary data and clarifications for all equation calculations above.

Table 1. Amount of phosphorus fertilizer (P_2O_5) per unit of harvested area

			ereals		Roots and	Sugar	Oi	ilseed crops	6			
	Wheat	Rice	Corn	Others	Tubers cro	crops	Soybeans	Oil palm fruits	Others	Vegetables	Fruits	
Bangladesh (B)	0.021	0.024	0.026	0.025	0.015	0.043	0.034	0.037	0.024	0.023	0.024	
Thailand (T)	0.035	0.007	0.018	0.005	0.017	0.052	0.033	0.035	0.010	0.059	0.026	
Avg. value of (B and T)	0.028	0.015	0.022	0.015	0.016	0.047	0.033	0.036	0.017	0.041	0.025	

(tonnes/ha)

Source: FAO, 2010

Note: P₂O₅ stands for phosphorus pentoxide. This research examines only P flow from agriculture to hydrosphere. Therefore, all data related to P₂O₅ are converted carefully by multiplying a conversion factor of 0.4364 to estimate the P flow from fertilizers to the hydrosphere.

Crops of 41 types are included in this research by classification respective aggregated items provided by FAO, 2010: Cereals (wheat, rice, corn, barley, rye, oats, millet, sorghum and other grains), Roots and Tubers (cassava, potatoes, sweet potatoes, yams and other potatoes), sugar crops (sugar cane and sugar beet), oilseed crops (soybean, oil palm, ground nuts with shell, sunflower seed, rapeseed, mustard seed, seed cotton, coconuts, sesame seed, olives, other oilseed crops), vegetables (tomatoes, onions and other vegetables), and Fruits (orange/mandarins, lemons/limes, grapefruit, other citrus fruits, bananas, plantains, apples, pineapples, dates, grapes and other fruits).

Harvested area data for each targeted crop for 2010 were obtained from the FAOSTAT web site. Total amounts of P fertilizer applied to crops of each type were referred from IFA data (Heffer 2013). Nevertheless, regarding P_{CROPi} , which simply represents the fertilizer usage by crop, no hard data or recorded information of actual usage exist in Myanmar. Therefore, because of unavoidable difficulties related to data availability, we take the average value of actual usage of P fertilizer amount per crop of Thailand and Bangladesh reported by Lwin et al. (2016, 2017). We agree that the use of fertilizer per hectare is expected to differ even for the same crop in different countries. The fertilizer use efficiency and intensity of each country vary considerably, reflecting factors such as agro-ecological resources (soil texture, terrain, and climate) and economic incentives. However, the effects of average values of Myanmar neighboring countries (Bangladesh and Thailand) might be less because they use similar technologies and plantation methods with similar plantation seasons.

After the harvested area for agriculture for crop of each type in each country for 2010 was obtained from FAOSTAT, future estimation of harvested areas during 2020–2100 was conducted under three scenarios as referred from reports of work by Tamura et al. (2015) and Tamura (2016): (1) Additional global harvested area demand for specific crops was allocated to countries assuming constant shares of the countries in expanded harvested areas of the specific crop; (2) Additional global harvested area demand for specific crops was allocated to countries; and (3) Additional global harvested area demand for specific crop was allocated to countries assuming constant shares of the countries in harvested area of the specific crop. Moreover, other estimated data related to future demand such as population, gross domestic product (at purchasing power parity) per capita [GDP/cap (In\$/cap)], and shares of rural and urban population, are taken from some parts of Shared Socioeconomic Pathways Scenario 3 (SSP3) provided by the International Institute for Applied Systems Analysis (IIASA): SSP3 denotes "fragmentation," whereby high population growth and low economic growth occur.

No direct data exist for R_{ls} and R used in equation 1 above. Therefore, we set their respective definitions and calculate respective values based on a review of the literature. Ratios of P return to farm from livestock manure (R_{ls}) were obtainable by dividing the quantity of P in animal excreta returned to farms by the total amount of excreta. The ratio of P outflow to water from farms (R) is estimated by dividing the quantity of P in excreta outflow to water from farms by the total P input to farms. For those two parameters we defined earlier, there is no specific research done yet for Myanmar. Therefore, we apply global data $R_{ls} = 0.533$ and R = 0.327 referred by Lwin et al. (2016, 2017) as an option for us to conduct this research.

Related to the ratio of *P* contained in the societal excrement returned to the farmland (R_e) , we divided countries into three groups: Group I countries with developed economies; Group II countries in economic transition; and Group III countries with developing economies (UN 2014). For group 1 countries, we assumed R_e as zero, but for Groups II and Groups III, we use 0.975 of Ma et al. (2013) for rural areas, with R_e set as 0 in urban areas. The shares of population in urban and rural areas are estimated from SSP3 scenarios. Myanmar falls into group III. Therefore, $R_e = 0.975$ is assigned for rural areas and 0 for urban ones.

Regarding P flow from livestock estimation, animals of five kinds were examined: beef cattle, dairy cattle, pig, layer chicken, and broiler chicken. Total numbers of livestock units in equivalent Japan livestock in 2010 were calculated for Myanmar using the methodology reported by Lwin et al. (2016, 2017). For future estimation, we referred the absolute number of livestock units in Myanmar from Tamura et al. (2015) and Tamura (2016). Those numbers of livestock units were estimated along with demand for food. Growth ratios of absolute numbers were calculated for each 10-year study. Then we multiplied those ratios by our estimated total number of livestock units, in equivalent Japan livestock units, starting from 2010. In doing so, the change over time of the number of livestock units was estimated for all study periods (2010–2100).

Per-capita phosphorus units in human excrement ($P_{person,e}$) and per-capita phosphorus units in gray water usage (($P_{person,g}$) vary by type of diet, location, age, activity, health status, tradition and culture, etc. Few measurements have been reported of amounts and compositions of human waste and gray water usage. Because this research was conducted under "system-wide" strategies, we use global conventional data of per-capita *P* units annually contained in human excrement (urine + feces): $P_{person,e} = 0.55$ kg/cap/yr, $P_{person,g} = 0.08$ kg/cap/yr as reported by Otterpohl (2003).

Another parameter SC used in equations, the percentage of population with access to sewage treatment facilities (STF), was referred from our earlier research (Lwin et al. 2015). We made the assumption that the ratio of residence connected to sewage treatment facility is a function of gross domestic product (at purchasing power parity) per capita (GDP PPP per capita in In\$/cap). If economic conditions improve and if the population increases, then necessary public environmental utilities such as sewage treatment facilities will be demanded to a greater degree in the hopes of raising the standard of quality of life. In other words, increased resource consumption and increased demand are expected to produce more sophisticated infrastructure requirements. Using such assumptions, future percentages of population connected to sewage treatment facilities can be estimated for individual countries under high scenarios and low scenarios.

The average P removal ratio (PR) in STF was estimated based on literature reviews of studies conducted for specific countries (Liu 2005, JSWA 2009, Stricker and Heduit 2010) and per-capita GDP PPP reported for the respective countries as follows. Based on GDP/cap (GDP per capita) in 2010 current US\$, countries were categorized by Anh-Nga Tran-Nguyen and Elkhoury (2010) as low-income (less than 800 US\$), middle-income (between 800 US\$ and 13,194 US\$), or high-income (over 13,194 US\$). Based on many reports of the literature related to STF, we assigned the maximum 30% phosphorus removal ratio in STF for low-income countries as the first

group, 50% for middle-income countries as the second group, and 80% for highincome countries as the third group. For estimation of the future P removal ratio, we used GDP/cap (In\$/cap) from SSP scenarios. Therefore, the current US\$ assignments presented above are transformed in GDP/cap (In\$/cap). We assign the PR setting as shown in Table 2. Country PR is considered based on the GDP/cap (2010 In\$/cap) change during the study period: 2010–2100. However, Myanmar falls into the categories of second group throughout the study period. A linear function is used to assess all possible trends of PR ratio during 2010–2100. Therefore, PR of Myanmar shows rates starting from over 30% and ending at about 50%.

Table 2. Average phosphorus removal ratio (PR) setting based on per-capita GDP PPP

Per capit GDP PP	ll Less than 694 [In\$/person] First Group	Between 694–11,455 [In\$/person] Second Group	Over 11,455 [In\$/person] Third Group
PR	30%	50%	80%

We assign a crude P-removal ratio scale indexed to a country's income ignoring types of wastewater treatment such as mechanical treatment, biological treat, etc. We regard our work as a top-down assessment first step that is particularly relevant to analysis of the development paths of economically developing countries, which lack large amounts of relevant data.

Results and discussion

This section presents an explanation of how much P flow from farmland, livestock manure, human excreta, and graywater usage passes to the hydrosphere.



Figure 2: Annual P flow from farmland to the hydrosphere: (a) scenario 1, (b) scenario 2, and (c) scenario 3.

Based on the amount of P used in mineral fertilizer in the expanded harvested area, P flow from farmland to the hydrosphere differs. Figure 2 presents the P flow from fertilizer under Scenarios 1, 2, and 3. Results show that Scenario 2 has the lowest P flow to the hydrosphere. Scenario 1 of P flow from farmland to the hydrosphere stands as the highest. Scenario 2 of P flow from fertilizer to the hydrosphere stands as the lowest, coinciding with the lowest demand of P in mineral fertilizer under Scenario 2.



As shown as in Figure 3, a markedly increasing trend is especially apparent for P flow from livestock during 2010–2100. P flows from livestock in 2010 were 12 thousand tones, but it becomes a twofold increase by 2100. No great change was found in the P flow amount during 2040–2090; it is about 25 thousand tonnes. However, from the overall study period (2010–2100), one might infer that, because of economic growth, livestock demand increased. Consequently, it results in gradual enlarged P flow from livestock manure to the hydrosphere.



P flow from domestic wastewater under high and low scenario of sewage connection

Figure 4: Annual P flow from domestic wastewater to hydrosphere.

The amount of respective P flow from societal excrement and graywater under high and low sewage connection scenarios are portrayed in Figure 4. The total P flows from domestic wastewater (societal excrement and graywater) during the study period are almost 13–20 thousand tonnes under low and high scenarios. The result is overwhelmed by the P flow of direct discharge from human excreta. That is true because, in Myanmar, only a small share of the urban population has access to STF and that the *SC* is expected to be 5.7% by 2100. Moreover, under our assumptions related to per-capita GDP and *PR* in STF, P removal ratio *PR* will be between 30% and 50% by 2100. As an overall trend, a gradual increase in P flow into the hydrosphere is observed in relation to increased urban population.

Combined scenario results

The P flows from agricultural and domestic wastewater under the six scenarios described in Table 3 are portrayed respectively in Figure 5.

Table 3. Composition of six scenarios estimating P flow from agricultural and
domestic wastewater (2010–2100)

Scenario Name	P flow from	n agriculture	P flow from domestic wastewater		
	P flow from farmland	P flow from livestock manure	P flow from societal excrement	P flow from gray water	
Α	PF _f (Scenario 1)	PF_m	PF _e (high)	PF_{g} (low)	
В	PF _f (Scenario 2)	PF_m	PF _e (high)	PF _g (low)	
С	PF _f (Scenario 3)	PF_m	PF _e (high)	$PF_{g}(low)$	
D	PF _f (Scenario 1)	PF_m	PF _e (low)	$PF_{g}(low)$	
E	PF _f (Scenario 2)	PF_m	PF _e (low)	$PF_{g}(low)$	
F	PF _f (Scenario 3)	PF_m	PF _e (low)	$PF_{g}(low)$	



Figure 5: Composite depiction of six scenarios estimating P flow from agricultural and domestic wastewater (2010–2100).

All scenarios resulting in P flows show that over 70% of P flow is accounted for by P flow derived from fertilizer, mainly because of farmland expansion. Comparison of the results of six scenarios (Fig. 5) demonstrates that Scenario D stands as the highest P flow, with Scenario F as the least scenario.



Amount of maximum and minimum P recovered by sewage system introduction

Figure 6. Amount of maximum and minimum P recovery potential to be used as fertilizer

Figure 6 exhibits the amount of P that can be recovered and reused as P in mineral fertilizer. Here, it is assumed that all P in domestic wastewater is collectable at sewer treatment facilities. If proper P recovery equipment was introduced into STFs, then a total of maximum 73 tonnes of P would be potentially recovered in 2010 under high sewage connection condition and minimum 54 tonnes of P under low sewage connection, as shown in Figure 4. That amount could reach over 571 tonnes (maximum P recovery amount) and 204 tonnes (minimum P recovery amount) respectively by 2100 according to the improved SC. The potential amount of P recovery is extremely small because the major P flows to the hydrosphere are from agriculture and population connected to the sewer system by sewer pipes is quite low in Myanmar.

Needs for the future

A main policy objective of the Government of Myanmar is to increase food security and the quantity, quality, and variety of crops through partnerships and through private sector investment. Improving private sector participation in the trade and distribution of fertilizer and sharing agricultural knowledge can reduce fertilizer costs and increase their correct usage, thereby improving farm productivity and food security and also leading to a safer environment. However, the necessity of formulating a series of cost-effective policies and best management practices (BMPs) in agriculture persists to this day. Consequently, the need exists to achieve more sustainable strategies that can handle nutrient flows from fertilizer usage to the hydrosphere.

Many challenges persist in relation to Myanmar sewage and sanitation because of many factors: (a) Operating treatment plants are still costly, even when proper treatment plants are available. (b) Lack of budget, technology, and experience are still unavoidable conditions. (c) High threats to environmental related issues exist because small and medium industrial zones rarely use proper treatment systems for wastewater disposal.

Currently, Myanmar sewage and sanitation must be responsible only to government. Future sewage and sanitation systems should be updated by law. In addition, with aid from INGOs and UN agencies, along with private sector participation, Myanmar sewage and sanitation must be improved in the future.

Conclusion

This study elucidated future trends of phosphorus flows from agricultural and domestic wastewater based on scenarios of numerous parameters that include economic development, population, livestock demand, harvested areas, and phosphorus removal rates in improved sanitation facilities in Myanmar for 2010–2100. Results reveal that phosphorus flow from agriculture exists on the range of 104–117 thousand tonnes. The P flow from livestock is 12 thousand tonnes in 2010: it is expected to double by 2100. Phosphorus flows from domestic wastewater are expected to be 13–20 thousand tonnes during the study period. It is expected that recovery of phosphorous from sewage sludge can be managed in the future.

As pioneer research for Myanmar, P flow from agricultural and domestic wastewater was estimated. As described earlier, in general, no hard data are available for fertilizer usage by crop in Myanmar. Development of estimates (if not guestimates) requires expert knowledge, i.e. communication with agronomists with extension services and fertilizer suppliers. Producing a P flow database for Myanmar is our ultimate mission. By collaborating with agricultural experts and considering actual usage amounts of phosphorus fertilizer usage by crop type, future national research is expected to provide a core for the appraisal of P utilization and to facilitate determination of important objectives for sustainable P management for Myanmar.

Moreover, this study mainly uses some parts of SSP3 scenarios. Future studies should use other scenarios (SSP1, SSP2, SSP4, and SSP5) with mutual comparison of their results. Inference of the underlying reasons for the results should be done to ascertain the relative priorities and to facilitate investigation, which is necessary for policymakers to elaborate appropriate frameworks for sustainable P management in Myanmar.

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Sustainability Should Be Fun. Designing Boardgames to Teach Sustainability

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Abstract

Teaching sustainability to undergrad students, particularly those in design degrees, faces barriers when it comes to relate core concepts such as the triple bottom line (environment, economy and social issues) or the environmental impacts of technological development with the product's life cycle in their design process or even their daily lives. It results in difficulties to understand and apply the knowledge due to the lack of practical learning when it comes to the topic. Game based learning has proven a good tool to raise understanding of certain topics, within a fun, flexible, and risk free environment that enables lateral and critical thinking. Boardgames are an accessible way to put into practice such concepts and improve understanding through play, experimentation, interaction, and repetition, combining theory with practice, thus they could help design educators to tackle sustainability issues with their students. The aim of this paper is to present the findings of a research project whose objective was to develop and test a board game with sustainability as main theme for use, within a framework of knowledge transfer, as learning tool in sustainable design courses at undergrad level.

Keywords: sustainability, game-based learning, knowledge transfer, boardgames, innovation

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Introduction

Sustainability has become a major theme to consider in terms of education in higher degrees such as design, mainly due out the impact that such careers have in social an environmental terms (Papanek, 1972). However teaching sustainability faces certain barriers, as the knowledge transfer process faces the obstacles of relating the knowledge to the students' daily life experiences or how to apply sustainable thinking on their projects. Thus a proposal to overcome such obstacles and improve the students' grasp of sustainability is the use of boardgames. There is a considerable body of research on game based learning, as it has proven to be an useful tool in the teaching of conflict resolutions, strategic and lateral thinking and cooperation in a safe and dynamic environment that provides hands-on practice of theoretical knowledge. It is because of those advantages that boardgames can be used as an economic medium to teach basic sustainability concepts such as the Triple Bottom Line, the Tragedy of the Commons and how technology growth impacts the environment.

The aim of this paper is to report on the initial findings from testing a game designed for such purposes.

Methodology

This game comes about as result of a research project that explored the possibility of developing boardgames to teach sustainability to design students. The earlier stages of the project involved the selection of the concepts to use as theme for the board game (In this case the Triple Bottom Line, the Tragedy of the Commons and technological impact), the viability of using commercial games for such ends in order to generate guidelines for a game prototype that was designed and tested with three groups of students. For the purposes of the testing, two models of knowledge transfer and game based learning were used to evaluate the developed game and how effective it was. Three tests were carried out with design students, with surveys applied before and after each teste to measure their previous knowledge on sustainability and any potential improvement of the same. As well after game sessions of discussion between the players were hold to gather insight on how the related to the game and the knowledge purported to transfer.

The first model was the Knowledge Transfer Model (see figure 1) developed by Major y Cordey-Hayes (2000). This model describes a basic process in which the data is collected and translated through a re-contextualization, codification and application of nuggets of information. This model was chosen because it fits with one of the most common definitions of a board game: an interactive mathematical system made concrete and used to tell a story (Daviau, 2011). In this case sustainability is the 'story' and the mechanics are used to teach the relationship between the previously noted concepts.



Figure 1: Knowledge Transfer Model (Major and Cordey-Hayes 2000)

The second model is the GIIL Model (Game Involvement and Informal Learning Framework) (see Figure 2) developed by Iacovides and her co-authors in 2014. Initially developed for videogames, it is considered that it can be applied to boardgames as well. It's composed of three sections, starting with the players' involvement, which can be at micro level (learning directly from the game) and at macro level (learning from activities related to the game, such as discussions, use of social networks to exchange tips, etc.) (Iacovides, et. Al., 2014). These levels have an impact on the awarness level related to a particular subject and the skills developed to understanding and applying it.



Figure 2: Gaming Involvement and Informal Learning Model (Iacovides, et. Al, 2014)

Teaching Sustainability

To teach sustainability, a multi-disciplinary approach is required, given how many diverse elements are involved. Thus it is needed to develop holistic methods to teach it (Bhamra & Lofthouse, 2004). Given that most students feel sustainability as something detached from their daily lives, they see it as an add-on to their projects (Sterling, 2001) or a mere technical problems to be solved, ignoring the social context and impacts (Humphries-Smith, 2008), rather than a philosophy from which draw guidance to develop their projects.

These approaches require the learning that develops creative solutions, iterative process and hands-on work. This is because people tend to remember 80% of what they do, compared to only the 10 to 20% of what they read or listen (Bhamra & Lofthouse, 2004).



Figure 3: Meaningful Learning percentages

Thus, to generate meaningful learning, sustainable theory has to go paired with interactive exercises that allow the student to give the knowledge meaning and relevance related to their daily lives, through reflection upon those exercises (Treher, 2011). This is where learning through play enters the picture.

Learning through play

The concept of learning through play is used as a very efficient way to be used during human development, helping to the mental and physical growth of the person. As well it helps to reaffirm aspects such as personality and the ability to solve problems. Within the classroom, the use of play allows improving creativity and lateral thinking, improves communication and eases the teaching process, making it an engaging experience and enhancing the retention of information. Through games, users can undertake different roles, understanding different points of view that they would not normally experience.

Gilbert Ahamer (2006) argues that games as tool for teaching help to promote a more complete learning, with both theoretical and practice aspects obtaining a stronger link to the students' life experiences and thus the implementation of such knowledge in their projects. It can be argued that boardgames allow to explore scenarios within a safe environment, reflect upon successes and mistakes and generate new ways of thinking, as well and enhancing the social experience of playing them (Lazzaro, 2004).

Boardgame basics and guidelines

People play boardgames for one or several of the following reasons, according to Nicole Lazzaro (2004):

- 1. *Hard Fun:* Players like the opportunities for challenge, strategy, and problem solving.
- 2. *Easy Fun:* Players enjoy intrigue and curiosity. Players become immersed in games when it absorbs their complete attention, or when it takes them on an exciting adventure.
- 3. *Altered States:* Players treasure the enjoyment from their internal experiences in reaction to the visceral, behavior, cognitive, and social properties.
- 4. The People Factor: Players use games as mechanisms for social experiences.

As mentioned before, boardgames can be defined as "an interactive mathematical system, made concrete, used to tell a story" (Daviau, 2011). In other words, a game is a set of rules and mechanics (depending on luck, strategy or both), designed into a set of components (boards, paper, dices, graphics) and that have a theme or themes that provide a wider framework within the minds of the users.

Game developers usually follow this sentence to describe and thus ground the basic concept of the game (Forbeck, 2011):

"[Game name] is a [category of] game in which [the players or their avatars] [do or compete for something] by [using tools the game provides them]" (Forbeck, 2011. p.p. 21)

This structure can be applied as well to this project when defining the theoretical frameworks under which work to develop games with sustainability topics.

There are three main types of boardgames, mostly derived of how game theory is understood¹, the kind of interaction required from the players (Zagal et al, 2006) and the final aim of the game in question:

•*Competitive games:* they require developing a strategy opposing the actions of the other players in order to win. They range from the simpler such as Monopoly and Risk to more complex games such as Magic the Gathering.

¹ Game theory is a branch of mathematics that studies through models the interaction between two or more actors and how their decisions have an impact in their interactions. In other words, every human interaction is a game where the decisions taken today affect the decisions that will be taken in the future and the response they will get in a feedback loop, studying how we make decisions (Stokel-Walker, 2015).

•*Cooperative games:* while allow only for a winner, they require that players have at some stage of the game objectives that are compatible or allow for trade and alliances. A good example of this kind is Settlers of Catan.

•*Collaborative games:* Often seen in horror themed games, these require that all players agree in coordinating common strategies to win, since the rival is a 'virtual' foe (or in some cases a single player opposing the rest in a different role). Either all of them win or lose (albeit some games allow for acceptable 'losses'). Examples are: Witch of Salem, Mansions of Madness and Fury of Dracula.



Figure 4: Examples of boardgames. From Left to Right: Magic the Gathering (Competitive), Settlers of Catan (Cooperative) & Witch of Salem (Collaborative).

Using commercial games as base as well as these basic concepts, a series of guidelines were developed to design the proposed game:

1. The game should allow for metagaming and improvement, in order to engage the players and thus be able to raise awareness in a practical way, of the sustainability.

2. As this is a game aimed to designers (albeit not necessarily exclusive to them), it should ask for problem solving and designing elements of the game to achieve those solutions.

3. Open the possibility of developing a game with a single winning objective but different options to achieve it.

4. Design mechanics that reflect how the decisions taken earlier in the games do have a meaningful impact on how the game develops over future turns.

5. The game should have clear, concise, easy to understand rules, in order to minimize the learning curve and increase player identity with it.

6. The game should provide enough complexity to generate metagaming, identification and high values of replay to keep the players/students engaged, but not excessively complex that they feel frustrated or disinterested in playing.

7. It is necessary to incorporate mechanics that make the player to think in terms of environment and societal development and not just economic issues and trade, in order to punish or reward players accordingly and to enforce the idea that the winning scenario involves thinking on those three dimensions.

The developed game

The developed game, going by the name 'Vessel Planet Earth' is a cooperative game whose basis are the Triple Bottom Line, technology development impact and the Tragedy of the Commons. In it, the player represents a region with certain amount of resources that can renew or trade to use them to buy technology, with the aim of achieving space faring technology while remaining a sustainable region by balancing their triple bottom line to reach certain set value in all spheres at the same time. The first one to achieve such technology wins the game. But each purchase of technology generates a cumulative impact on Earth. When these impacts reach a milestone a natural disaster that affects all the players equally is triggered. The players can as well 'reinvest' their resources to balance their triple bottom line (investing in their environment, society and economy in other words) to make their region able to withstand a disaster. Once a certain number of disasters have occurred, the game ends for all players as a loss since this symbolizes the destruction of the planet.



Figure 6: Vessel Planet Earth

Test and results

First Test

Characteristics of the first group: it was composed by 4 players, 3 of them design students (one was a guest of elementary school age, which provided the unexpected opportunity of testing the game with younger audiences) and a facilitator to explain them the game while the researcher took notes and video.



Figure 7: First test group

Reflections & results of the first test: the players enjoyed the game as they considered that it showcased the interconnection between regions and how actions and decisions impact everyone and not only the environment of their region. They came to the realization that in a technological race, the first loser will be the environment, as people will prefer to exploit resources in their benefit rather than supporting and collaborating with others. As well they noticed that they cared only of their triple bottom line when a disaster hit them, hindering their chances to win. This first test as well helped to refine some of the mechanics of the game as well as the amount of cards available to play.

Knowledge Transfer Model evaluation of the first test: the results of knowledge transfer, analyzed with the help of the surveys and the after game session show an improvement on the awareness by the players on how delicate is the balance of the triple bottom line and how easy is to impact negatively the environment with ill thought technology projects. Also they mentioned the impact of selfish decisions compared to that of collaborating for a common goal.

GIIL Model evaluation of the first test:

•Micro level involvement: the players took their time to analyze the mechanics of the game to develop winning strategies. One of the most cited strategies was to maximize first their triple bottom line markers in order to purchase technology without care of any possible negative impact or disaster.

•Macro level involvement:

-After game discussion: the excitement from playing the game was enough to encourage a lengthy discussion on how to improve the mechanics, the knowledge learned and which decisions they would take differently to avoid destroying the planet.

-External resources: this particular group of students (with the exception of the guest) where undertaking the 'Sustainable Design' class at the moment.

• Increase of knowledge/skills: players showed a better understanding of the Tragedy of the Commons and how their individual decisions impacted the environment, as well as how hard is to balance the triple bottom line in real life and how they need to consider the impact that their proposed design projects could have on the environment.

•Identification with the game: the level of identification and immersion with the game by the players allowed them to play without noticing the length of the session (it ran for two hours). As well they considered that the game reinforced the themes studied in their class and in the case of the Tragedy of the Commons, clarified how it worked in real life.

Second Test

Characteristics of the second group: it was composed by 4 players, design students and a facilitator to explain them the game while the researcher took notes and video.



Figure 8: Second test group

Reflections & results of the second test: it took to rounds for the players to get involved with the game and to get a grasp of the rules. In general this group was careful when acquiring technology because they were aware of the negative impact implications; this slowed the game but minimized the risk of triggering a disaster. This group started a reflection upon how certain technologies have a bigger impact on the environment than others. It was derived from the shared attitude of thinking forward and considering the impact of their choices, including working in conjunction even if that meant that they would be helping a rival to win.

Knowledge Transfer Model evaluation of the second test: the results of knowledge transfer, analyzed with the help of the surveys and the after game session show an improvement on the awareness by the players on consumption impacts the environment and related it to the topics seen in their classes. They realized how the choices they made when developing a design project could have both positive and negative impacts on the environment and society, as well as the need for forward thinking and long term planning.

GIIL Model evaluation of the second test:

•Micro level involvement: the players realized the link between technological advancement and environmental impact. They developed joint strategies of trading resources and technology purchase in exact amounts to reduce waste. As well, once the first disaster was triggered, the players shifted towards a more conservative strategy to avoid that happening again.

•Macro level involvement:

-After game discussion: the players mentioned how it would be good for the game to include other concepts such a life cycle of products. As well they noted how during the first rounds the careless management of resources and technology reflected the current way society consumes products and generates waste.

-External resources: this particular group of students had already taken the 'Sustainable Design' class of their program.

• Increase of knowledge/skills: players showed a better understanding of the following topics: the hardship of balancing the triple bottom line; the relationship between economic activities and environmental impacts and the concept of sustainability, given that they had on their own words 'a more realistic' practice of what sustainability is through the boardgame.

•Identification with the game: this group felt immediately identified with the game (to the point the wanted to participate in future sessions) and mentioned how the game made clearer the concepts they barely paid attention to when they took the class.

Third Test

Characteristics of the third group: it was composed by 4 players, design students (one of them had never taken any sustainability related class, thus all the concepts on the game were brand new for her) and a facilitator to explain them the game while the researcher took notes and video.



Figure 9: Third test group

Reflections & results of the third test: this group showed bigger involvement with the game, including making jokes between rounds. They grasped the rules of the game faster than the other groups, playing without the help of the facilitator. They realized
that human activities such as heavy meat and milk consumption had a considerable impact on the environment. In this group the players were acting in a more altruistic way, trying to minimize the environmental impact. This took place after a player declared to feel guilty about triggering a disaster during the earlier rounds, with all the negative consequences that implied (after previously having a nihilistic point of view about 'purging the planet'). However they barely cared about balancing the triple bottom line unless they had no more choices during their turns.

Knowledge Transfer Model evaluation of the third test: the results of knowledge transfer, analyzed with the help of the surveys and the after game session show that this particular group gained an increased comprehension of the topics seen in class. In the case of the student that hadn't take the class yet, she mentioned to have now a clearer idea of what sustainability is and how technology affects not only the environment but people's lives, thus the need to be more careful on what to design and how.

GIIL Model evaluation of the third test: Micro level involvement: this particular group showed more interaction in earlier rounds, generating collaboration strategies about resources trade and management, increasing the speed of the game and reducing conflicts.

•Macro level involvement:

-After game discussion: the players of this group created jokes and talked about their realizations on how consumption generated environmental impacts, altering their shared strategy towards a collective benefit in order to avoid triggering a natural disaster.

-External resources: this particular group of students, sans one had already taken the 'Sustainable Design' class of their program.

•Increase of knowledge/skills: players showed a better understanding of the following topics: what's an environmental impact and how it results from human economic or technological activities; how easy is to forget about the triple bottom line when working on a design project and how cooperation brings more benefits to everybody on the long term.

•Identification with the game: this group considered the game so fun that felt disappointed when the test had to end. In the case of the student that had no taken any class on sustainability, the game helped her to understand better the basic concepts that she had heard from her classmates. This group suggested adding to the game a 'Curious Data' sheet to explain real life facts regarding environmental impacts. Finally, they realized that natural disasters impact everyone, regardless of their location.

Reflections and conclusions

When the project started, it parted from the following hypothesis: *if a boardgame with sustainability as core theme is developed as tool for meaningful learning, it would be possible to enhance the understanding of sustainability basic concepts.*

Based in the results obtained from these three tests, including the surveys, it seems that it is not only possible to develop such game, but shows promising signs of helping the students to get a better understanding of sustainability. However it is recognized the need to do a more continuous study on the application of this tool. It has to be noted that games can only be used so far to convey knowledge based on how long they can be played during a regular session. More complex situations might require more complex games with all the challenges they imply. There is also the need to define more concepts that can be translated to new games, such as Life Cycle Assessments or sustainable urban planning.

Games like 'Vessel Planet Earth' can help as tools for meaningful learning in a safe environment that allows for trial and mistake, practical experiences to go in conjunction with regular lessons. Games are proving to be a useful tool to overcome most common barriers when teaching sustainability in a more engaging and meaningful way.

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Differences in CSR Activities and Employee Perceptions in Family-Run Businesses in Eastern Thailand

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Abstract

Many Thai scholars have suggested that Corporate Social Responsibility (CSR) practices in Thailand have been a result of influences by foreign companies, many of which have active and typically formalised CSR programmes. However, family-run businesses in Thailand (FRBT) often practice a different form of CSR, driven by the desire to "give back to society", influenced by religion and culture. Previous studies have stated that CSR practices may vary between different firm types. This paper explores differences in approach to, and practices of, CSR in FRBT, in particular sectorial differences how different business sectors of FRBT practise their CSR activities and how such activities are perceived by their employees.

The research is based on 2,352 returned questionnaires from employees of 28 FRBs in Eastern Thailand. Overall, the results show strong appreciation of the intrinsic CSR activities with interesting gradients across 3 FRBT sectors. Perceptions of CSR practice were clustered and labelled as: 1) Inactive CSR 2) Active CSR 3) Caring company 4) Moral owner 5) No CSR, with a clear split in distribution between hotels, fruit processing, and jewelry sectors. In addition, staff from the jewelry sector appear happier than others probably because they appreciate the strategic intent of the CSR activities and have better awareness of the business owners' generosity. Employees from the fruit processing sector appear the most disaffected because they perceive less CSR actions of their company. CSR awareness and perception of employees in the hotel sector generally vary much more depending on their working hierarchy in their respective companies.

Keywords: Corporate Social Responsibility (CSR), Family-run Businesses in Thailand (FRBT), employee perception, Small and Medium Enterprises (SMEs)

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1. Introduction

Family Business Circumstance

Multinational companies and large companies established around the world are significant in today's time. Nonetheless, FRBs also contribute vastly to the world economy and workforce. Shanker and Astrachan (1996) stated that 12 to 49% of the total GDP and 15 to 59% of the U.S employment was contributed by family firms (Sharma, et al., 2001). Littunen and Hyrsky (2000) claimed that there has yet to be a widely accepted definition of FRBs although literature offers many and various definitions (Astrachan, et al., 2002). Here, FRBs are defined as companies which are managed only by family members.

Previously, scholars globally have studied succession when they looked into FRBs and have found, amongst others, that the success rate of FRB succession has deteriorated over time (Sharma, et al., 2001; Sharma, et al., 2003; Sharma, et al., 2005; Handler, 1994; Morris, et al., 1997; Morris, et al., 1996; Bjuggren and Sund, 2001; Breton-Moiiler, et al., 2004; Cabrera-Suarez, et al., 2001). Similarly, Thai FRBs are also facing succession issues which is crucial because companies that are domestically owned are mostly family firms (Lawler, et al., 2006). Even though succession is studied much less in Thailand, researchers suggest that succession failures can be categorised into family dimension, transition plan, lack of successor's interest, and bad relationship between founder and successor (Handler, et al., 1988; Miller, et al., 2003; Sharma, 2004). However, some researchers found that human resources management can help improve succession possibilities. For instance, Astrachan and Kolenko (1994) specified that human resource management and practices, with the help of professional governance, aid in family firms' survivability. However, there is limited research on the relationship between CSR and FRB transition where CSR activities may be able to strengthen FRB transition processes and survival. This research argues that, apart from human resource management, CSR is another strong tool to support FRB in raising survival chances in the succession process.

Corporate Social Responsibility (CSR)

CSR has been studied and practiced in academia and organisations alike for decades (Carroll, 1911; Carroll, 1979; Jones, 1980; Greenwood, 2007; Friedman, 2009; Prayukvong and Olsen, 2009; Aguinis and Glavas, 2012; Glavas and Godwin, 2013). Over time, socialisation, diversification, national and local interpretation and changes in values and priorities has expanded the definition of CSR (Barmmer et al., 2007) Initially, CSR was known to have economic values to companies where profit maximisation can be obtained (Friedman, 2009 p.112) – and be promoted only to the extent it does. Jenkins (2004) stated that businesses' social responsibility originated from philanthropic donations and activities of large companies and individuals so actions such as endowing universities and establishing worker model communities are generally results of these large and wealthy companies. Later, CSR has been applied to address ethical standards for society and the company's stakeholders. Carroll (1979) argued that CSR expanded to cover economic, legal, ethical, and philanthropic aspects. Since the 1980s, scholars relate CSR to the stakeholder concept (Carroll, 1991; Freeman, 2010 p. 38) which recognises employees, suppliers, the community

and the surrounding society as legitimate parties of interest (Sims and Keon, 1997; Zaharia, 2011; Eua-anant et al., 2011; Lee et al., 2013). Recently, CSR has been defined by the World Business Council for Sustainable Development as "the continuing commitment by business to contribute to economic development while improving the quality of life of the workforce and their families as well as of the community and society at large" (WBCSD, 2017). Jamali and Mirshak, (2006) further argued that differences in culture matter for the CSR dynamics and are typically different between companies. This was supported by Perrini and Minoja (2008) who studied on CSR in Italian medium-sized FRBs and have found out that company owner's beliefs and moral values, and his past experience, seem to influence the CSR strategies of the company.

In Asia, it appears that many companies have been increasingly describing CSR as social and environmental effectiveness of their firms. Nevertheless, very few FRBs, especially in Thailand, have used the term CSR when describing such activities, although anecdotal evidence suggests that many FRBTs are actively pursuing their own understanding of "Social Responsibility", geared towards their employees and the communities they live in. This research will explore what CSR activities are being carried out by Thai FRBs, with a focus on CSR activities and their relation to employees.

Effects of CSR on employees

Human resource is an important function in managing and developing employees in an organisation. CSR can be useful for employee's engagement within the businesses as well. Goffee (1996) suggested that employees are controlled by control systems which focuses on the social and moral obligations and employees are expected to fulfil, and be loyal to, these tasks. In return, company owners pay employees but also may help with welfare of their employees such that they have better means to live. Employees are crucial since they allow companies to operate effectively and therefore both parties, employers and employees, are interested in this form of relationship (Greenwood, 2007). CSR creates trust and social capital from employees, thereby allowing employee policies to be more easily carried out and also brings out lovalty of employees (Perrini and Minoja, 2008). Employee motivation and happiness and be improved by CSR (Sims and Keon, 1997; Worthington, et al., 2006) and positive CSR reputation is able to create positive employee perception to the company (Turban and Greening, 1997). In most small firms, value congruence and trust is vital for the success of the organisation as coordination of work happens much more frequently and without formal procedures (Jenkins, 2006). Sims and Keon (1997) suggested that trust within the company can develop better in an ethical working environment, which in turn can help to reduce employee turnover rate. There is also a positive relation between happiness and ethical working climate (Sims and Keon, 1997; Waddock and Graves, 1997; Viswesvaran and Ones, 2002; Valentine and Fleischman, 2008; Lee et al., 2013). When there is a positive view on company's CSR, employees tend to be more positive towards other areas as well including senior management integrity, senior management leadership, and organisational competitiveness (Lee et al., 2013). Employees are mainly concerned with organisational survivability and the assurance of their wellbeing when companies practice a lot of CSR (Spence, 1999).

Recently, scholars have been researching more actively employee perceptions of CSR (Chew, 2015; Waddock, 2004; Peterson, 2004; Rodrigo and Aranas, 2008; Glavas and Piderit, 2009; Glavas and Godwin, 2013; Lee et al., 2013; Turban and Greening, 1997; Kim et al. 2010). Glavas and Godwin (2013) have developed a model of the impacts of employee perceptions of CSR and how it helps employee identification with the companies they work for. They also found that awareness of CSR activities positively affects employee attitudes, especially when the company is socially ethical or that the CSR activities are important to them. Lee et al. (2013) mentioned that companies can improve their performance by improving their CSR performance and their employee CSR perception. Chew (2015), in a study on CSR impacts of employees in Malaysian SMEs, found that good CSR practice on environment help organisations to improve employee participation in the company. Further, Rodrigo and Aranas (2008) stated that employee CSR perceptions derive from their attitudes on company and society which suggests that the social conditions of employees and their socialisation into the organisation play an important role in the derivation of CSR perceptions. Therefore, companies have to take into account the employee social conditions when implementing CSR activities or strategies.

In conclusion, many researchers suggest that, through CSR, a company can have better human resources performance in terms of staff loyalty, turnover rate, staff happiness and better working environment which is beneficial to the company itself. Since social conditions of companies among different sectors and countries can be different, it is interesting to look at CSR perceptions of employees across some of Thailand's sectors.

Nature of social responsibility in Thailand

In Thailand, many companies have been applying CSR practices in their organisation, especially for human resource purposes, influenced by the West (Brewster, 1995). CSR practices is defined here as activities performed by an organisation to initiate betterment towards society and their employees. Zhu et al. (2007) who studied on HRM in Asian characteristics stated that before 2000, HRM was prioritised on peerto-peer affinity and rewarding long-term employees rather than being performancebased. HRM, then, involved simple and informal practices such as staff employment, gauging employees' wages and employee rankings. In Asia, Thailand included, more companies are owned only by family members than other regions of the world (Bendell and Ng, 2009). Bendell and Ng (2009) suggested that being a FRB means that the company is not restricted by shareholders and so they are able to incorporate their own beliefs and interests into their companies. Especially in Thailand, CSR practices may not be formalised (Eua-anant et al., 2011) but are implicit, informal or intrinsic FRBs (Pravukvong and Olsen, 2009; Onozawa, 2013; He et al., 2015; Euaanant et al., 2010). Most large firms, especially in Thailand, often originated as family firms and some continue to be owned and managed in the same manner (Lawler, et al., 2006). This means that human resource management, and CSR, practices often appear less structured even though they can be effective (Lawler, et al., 2006). Information gathered from preliminary interview has suggested that FRBs owners favour close and long-term relationships with their customers and employees. These companies generally have equally flat organisational hierarchy structure. The company owner, often the family head, is usually the person in command when deciding what the CSR activities these FRBs should undergo, and with what effect.

Most FRBs in Thailand are SMEs that illustrate their family nature and therefore enhances the importance of traditional social networks (Bendell and Ng 2009). Zialcita (2011) stated that Buddhism is one of the three pillars of the Thai identity which appear to be heavily influencing the management of companies in Thailand. Similarly, Onozawa (2013) mentioned that FRBT practice CSR that is influenced by the notion of "giving back to society", which is often influenced by religion and culture. Looser and Wehrmeyer (2016) studied SMEs in Switzerland and have identified intrinsic CSR as "idealistic motives, visions, physical proximity, aspiration, and the will to give something back" (p.550). Likewise, intrinsic CSR activities are often designed based on traditional and ethical contexts. Therefore, businesses that incorporate intrinsic CSR are unlikely to apply formal CSR methods (Looser and Wehrmeyer, 2016). Nevertheless, the perception of CSR activities as seen by employees of FRBs with non-formalised CSR activities have yet to be looked upon in terms of their causes and effects.

Aim

This research aims to explore CSR activities differences across FRBs of 3 business sectors (hotel, fruit processing, and jewellery) in Thailand. This should help understand how intrinsic CSR activities are initiated, how they are different among companies of different business sectors and how they are perceived by employees across FRBs. The study will also explore how these CSR activities are perceived and with what effect. Ultimately, the results can then help to find ways to improve the working environment among the FRBs and increase the overall effectiveness in these FRBs.

2. Methodology

Data collection

This research is based on quantitative data analysis with the use of questionnaire surveys to investigate employee perception of CSR among FRBs. A preliminary interview phase was conducted where 17 FRB owners in Eastern Thailand were interviewed. These 17 owners own 28 FRBs of different sizes. After consent, 3,000 sets of questionnaires were distributed to the employees of these 28 FRBs with 2,684 anonymous responses returned. Collected data was then entered into Microsoft Excel for storage and the majority of data analysis was performed with SPSS.

Data analysis

Although a total of 2,684 respondents participated, some of the responses were omitted as they were largely incomplete, leaving 2,352 responses to be considered in this study. Procedurally, Factors were generated from the use of principle component analysis on the employee attitude and the employee perception data, then cluster analysis was performed in line with previous efforts (Laysiriroj, et al., 2017; Zierler et al., 2017; Jeswani, 2008; Thilmany, 2013). Cronbach's alpha was used to test the reliability of these Factors before they were used in further analysis. Only clusters with Cronbach's alpha of 0.7 or higher were considered to ensure the reliability of the results. Cluster analysis has been used by other scholars to differentiate and categorise

respondents into groups (Lindgreen et al., 2009; Taneja, 2011; Buciuniene and Kazlauskaite, 2012; Thilmany et al., 2013).

3. Results and Discussions

The 28 FRBs selected for this study included 20 hotels, 4 fruit processing companies and 4 jewellery companies of different sizes (2 micro small businesses, 13 small businesses, 12 medium businesses, and 1 large business). 2,188 respondents of consideration worked in the hotel sector, 65% of which were in medium-sized hotel. There was 1 large hotel which has employed 28% of the total amount of employees responded with a total of 7 managers. All the fruit processing companies were medium-sized companies. Approximately 83% of the respondents in jewellery sector came from small Jewellery companies and 16.7% came from the micro small companies of the sector.

The analysis found that the organisational structures of these FRBs are different: Only businesses in the hotel sector were found to have a more complex hierarchical structure where the owner is at top, followed by layers of Managers, Head of Sections, and Shop-floor employees. Fruit processing and jewellery companies have a relatively flat hierarchical structure where there is only 1 top manager which is the owner. These flat structured companies are often run by the founders, or the first generation of owners, of the company. On the flipside, 73% of hotel employees worked under the governance of the second generation owners while only 26.7% worked with the first generation owners. Respondents have suggested that all the jewellery companies were run by the first generation and the majority 63.8%) of fruit processing firms are managed by the first generation. Since Thailand is a Buddhist country, it is normal for 90% of the employees to be working for Buddhist owners, even when most FRB owners are Chinese-Thai, and 94% of these employees are Buddhists themselves. While there were 60 - 70% of female employees in the hotel and fruit processing firms, 60.4% of employees in the jewellery companies were male. The age group of employees are also different. Most employees in the hotel and fruit processing companies were between 21 - 40 years old while Jewellery firms' staff members are often aged between 41 - 50 years. Employees from the hotel sector have a higher average education level than the fruit processing and jewellery sector: Hotel workers often have at least a high school or bachelor's degree while many employees of the fruit processing and jewellery companies have lower education level (middle school or lower).

The data was then analysed using cluster analysis that yielded 5 clusters describing the CSR intensity as perceived by employees of the respective companies which is illustrated in Table 1. Likewise, a separate cluster analysis yielded another 5 clusters for employee attitudes in each company.

Clusters of CSR activities	Z	Cluster Definition
CSR Inactive	636	Employees do not perceive CSR activities. Employees believe that the company does not get involved with helping society and the environment. The company does not appear to provide safety precautions required for their jobs. They also feel that their boss does not treat them well enough. However, the company may put emphasis on training, providing basic needs such as food and shelter, and supporting employees with scholarships.
CSR Active	408	Employees are aware of CSR activities that the company has done for them and society. Employees believe that the company is involved in providing training for them. Basic necessities are also provided in terms of social (national) insurance, food, shelter and medication. The boss also supports workers with benefits such as education, welfare, religion and philanthropy.
Caring	512	Employees appreciate the benefits their staff receive from the company's CSR activities but may feel that the boss is less moral. The company is greatly involved providing training, meeting, basic necessities and problem solving for their employees. However, the employees are not touched by the actions of the boss since the boss has little integrity and is not approachable. The boss also does not treat the employees as family. They are also not providing enough societal and environmental aid.
Moral Owner	474	Employees perceive the morality from the head of the organisation (religious and integrity). Employees were trained by the head of the organisation and the head of the organisation is religious and is seen to have integrity so (s)he is approachable. However, the company lacks involvement in providing societal and environment aid and lack safety precautions for their employees.
No CSR	322	Employees do not perceive or recognise any CSR activities of the company. The company does not provide help to society and environment, lacks safety precautions and treats employees poorly. The company does not provide enough training, necessities (food and shelter), and benefits to their employees. Lastly, the company does not try to help their employees to solve their problems.
		TABLE 1: Identified clusters for CSR activities
Clusters of Staff's Attitude	Z	Cluster Definition
Highly Satisfied	457	Employees sense that they have more stability emotionally and physically while working in the company. They are satisfied with their salary and would remain loyal to the company even when other places offer them more. Working in this company allows them to become better people because they are taught moral values. Employees in this cluster like the working system in the company and feel that they have been treated fairly
Proud	479	Employees feel that they are capable of self-improvement. They are ready to be responsible for their actions. They are willing to help their colleagues and boss. However, they may feel that the working environment does not suit them. They may have problems working with their colleagues and be a part of the bigger family.
Disaffected	685	Employees do not like to work for the company and they feel that the company is not being fair. They would leave the company if they have better offers. They are not happy with their salary and working at this company does not provide them with stability.
Wage Oriented	464	Employees do not necessarily like to work for the company. They usually work for the money because they do not feel that they are being treated fairly.

boss.

267

Prideless

They do not like to work at the company and do not believe that they are in the right place. If they have better choices, they would leave. They have little self-improvement in terms of work and are not ready to be responsible for their actions. They also are less likely to lend their hands to colleagues and

They believe that they can still improve and be helpful to others and hopefully earn more

Family Firm	Sig.	Total		5 Clusters: CSR activities			
Sectors			CSR Inactive	CSR Active	Caring	Moral Owner	No CSR
Hotel	0.000	2,188	27.4%	17.9%	22%	19.9%	12.8%
Fruit Processing	0.000	116	27.6%	10.3%	19%	16.4%	26.7%
Jewellery	0.000	48	10.4%	10.4%	16.7%	39.6%	22.9%
Total	0.000	2,352	27%	17.3%	21.8%	20.2%	13.7%

Employee perception on CSR activities

Table 3: Results from employee perception on CSR activities clusters

Table 3 shows the frequency crosstabs between the 5 clusters of CSR activities across the 3 business sectors. There are clear differences in the perception of CSR activities between these 3 sectors: A significant 39.6% of employees in the Jewellery sector have described their companies' CSR status as a "moral owner" company when compared to 19.9% and 16.4% of the hotel and fruit processing companies respectively. Only 10.4% of employees in the jewellery sector labelled their company as "CSR inactive" which is less than half of the hotel and fruit processing sectors. This could be a result of their flat hierarchical structure and the size of the FRBs (small and micro small only) which enables these employees to work within close proximity with their respective company owners. Employees in this sector are often of higher age and have worked longer within the company than hotel and fruit processing sector which could be the result of the nature of a jewellery company where specific skills are required, acquired through prolonged training, in order to perform their work effectively. Thus, owners of such FRBs are motivated to keep a close relationship with these employees through the use of intrinsic CSR to gain trust and loyalty from these employees. This can be supported by (Worthington, et al., 2006) who stated that employers engage in moral and paternalistic approaches to care for the welfare of their employees because doing so could help to foster employee loyalty and commitment towards the company itself, improving the organisation as a whole in the long run.

On the other hand, hotel employees perceive the "CSR active" and "Caring" aspects of their companies more than other sectors. Also, employees of this sector have the least proportion who labelled their company as a company with "no CSR". This suggests that there is a standard procedure when it comes to CSR activities in hotels, especially when these hotel often have more employees than the other 2 sectors. The employees were able to recognise these CSR activities in terms of training, uniforms, food, accommodation, social insurance, and medication for wellbeing. Because hotels are bigger than the other 2 sectors in nature, the degree of formalisation within the organisation tends to be higher. Thus, FRB owners have to declare their CSR activities to their employees such that employees will know what benefits to expect when they work for the company. In a hotel, where businesses are medium or largesized, owners generally work more closely with the managers in the hierarchy system. CSR policies are brought up to managers who will then deliver them to head of sections and shop-floor workers accordingly. According to Laysiriroj, et al., (2017), CSR perception differ among hierarchies. Managers and head of sections usually have more favourable CSR perceptions than shop-floor employees. Family-run hotels often have high staff turnover rate, especially of low ranked employees because such position does not require a special skill set and CSR activities are more catered towards higher ranking employees who are less expendable. Thus, shop-floor employees in hotels may have less positive perception of the company CSR activities

which affects their satisfaction when working in the company, leading to lower commitment and loyalty and higher turnover rate. Many a time, hotel shop-floor workers put in effort into their work solely because of the benefits such as work experience and good salary (Laysiriroj, et al., 2017.

Spencer and Lozano (2000) explained that CSR in the context of SMEs involve improvements in terms of health, safety, work climate and productivity, and provide a platform for differentiation and visibility in the modern market. Morsing and Perrini (2009) suggested that CSR provides opportunities for companies to be more competitive. Despite these qualities of CSR and high competitiveness in the fruit processing industry in Thailand, it is surprising to see respondents from the fruit processing FRBs having negative CSR perception as compared to employees of the other 2 sectors. Table 3 highlighted that employees mostly perceive their company's CSR activities as "CSR inactive" and "no CSR". The "Moral owner" description was also mentioned least in the fruit processing companies. This is likely because the work process of the production is structured as a routine where shop-floor workers are responsible for operating fruit processing machines. Employee happiness affects quality of service more and because technology is used in the production of processed fruits, employee satisfaction is of less concern when it comes to the owners. Therefore, the majority of employees do not get to experience CSR activities by the company.

Employee attitude clusters

Family Firm	Sig.	Total		5 Clusters: Employee Attitudes			
Sectors			Highly Satisfied	Proud	Disaffected	Wage Oriented	Prideless
Hotel	0.624	2,188	19.7%	20.3%	28.9%	19.7%	11.4%
Fruit Processing	0.624	116	12.9%	20.7%	33.6%	22.4%	10.3%
Jewellery	0.624	48	25%	22.9%	29.2%	12.5%	10.4%
Total	0.624	2,352	19.4%	20.4%	29.1%	19.7%	11.4%

Table 4: Results from employee attitude on CSR activities clusters

Table 4 illustrates the 5 clusters of staff attitudes that was generated via the cluster analysis. The table clearly distinguishes employees into 5 characteristics with respect to the 3 business sectors. In Jewellery FRBs there is a highest proportion of employees who are "Highly Satisfied" and "Proud". The three sectors contain similar proportions of employees who are "Disaffected" with employees from fruit processing companies being slightly higher than the other 2 sectors. It is also notable that the amount of "Wage Oriented" employees among jewellery FRBs is at 12.5% which is significantly lower as compared to the hotel and fruit processing businesses. Fruit processing companies, in contrast, have the least amount of "Highly Satisfied" and the most amount of "Wage Oriented" and "Disaffected" individuals proportionately. "Highly Satisfied" and "Wage oriented" in the hotels is both at 19.7% which is in between the fruit processing and Jewellery companies. Although, only by approximately 1%, hotels have the highest relative amount of "Prideless" individuals. Overall, it appears that employees who belong in the Jewellery sector have characteristics which are more preferred by employers. "Highly Satisfied" and "Proud" individuals are more preferred because being happy and responsible allow for a better working environment and can turn into better effectiveness while working (Laysiriroj, 2017). "Disaffected" and "Prideless" characteristics are the traits that companies do not prefer as employees are not happy and have no room for improvement. However, employees from all 3 sectors have relatively similar amount of employees who fall under these categories.

Associations between CSR activities and employee attitudes

Results from previous cluster analysis have indicated that there may be a connection between perceptions of CSR activities. Therefore a crosstabs analysis between CSR activities perception and employee characteristics in the companies have been conducted. Table 5 illustrates the association between CSR activities as perceived by employees and the type of employees that work under these companies.

5 Clusters:	Sig.	Total		All sectors: 5 Cluster: CSR activities			
Employee Attitudes			CSR Inactive (N = 636)	CSR Active (N = 408)	Caring (N = 512)	Moral Owner (N = 474)	No CSR (N = 322)
Highly Satisfied	0.000	457	9.8%	45.1%	5.5%	38.3%	1.3%
Proud	0.000	479	8.8%	16.9%	40.3%	18.2%	15.9%
Disaffected	0.000	685	21.5%	8.6%	31.1%	23.8%	15%
Wage Oriented	0.000	464	71.6%	12.7%	5.8%	8.8%	1.1%
Prideless	0.000	267	26.2%	1.1%	20.2%	3%	49.4%
Total	0.000	2,352	27%	17.3%	21.8%	20.2%	13.7%

Table 5: Associations between CSR activities and employee attitudes clusters

According to Table 5, "Highly satisfied" individuals often label their companies as "CSR Active" and "Moral Owner" companies. This means that employees are able to reach out to their boss when there are disagreements as well as being able to appreciate the CSR activities that the company has directed to them. "Proud" employees are associated with companies they label as "Caring". "Caring" companies focus on the welfare of employees and thus employees are willing to work in these companies despite not having high salary. There is no clear cut association between employees who are "Disaffected" and what kind of company they label theirs. However, the closest connection is "Caring" companies with 31.1% of employees who call their company "Caring" are "Disaffected". This is because while they understand and recognise that the companies are providing benefits and engaging in intrinsic CSR activities, the CSR activities that were involved did not seem enough or have not met their needs and wants. There is a clear positive relationship between "CSR Inactive" companies and "Wage Oriented" employees. Employees in this type of company appear to be uninterested in, or motivated by social activities or ethical congruence, so they are mainly interested in economics. Employees who are "Prideless" are often associated to "CSR Inactive" companies and companies with "No CSR". Employees often feel that they have no other choice but to work for their current company because they may be earning just enough and would not be employed elsewhere.

4. Conclusions

The project shows that employees among different FRBs in the 3 business sectors have distinct CSR perceptions of their company. The pattern suggests that employees from the hotel and jewellery FRBs appear to have better perception of CSR activities of their companies. This CSR perception is then correlated to the employees' attitudes and characteristics whether it is because positive CSR perception influences positive attitudes of employees or employees with positive attitudes are attracted to companies with relatable CSR activities. The case of jewellery business indicates that positive

CSR perceptions create positive employee characteristics because of the long work length of the employees in jewellery FRBs. Likewise, negative CSR perception also brings about negative employee characteristics. It is an interesting find that highly satisfied employees are working in companies that they perceive as "CSR active" or with "Moral Owners". In contrast, companies that are perceived as "CSR Inactive" employ workers who are generally "Wage Oriented". This is highly indicative that a company's CSR performance is largely associated with the type of employees they are able to attract. However, there are also employees who recognise but do not appreciate CSR which has resulted in CSR activities creating negative or neutral attitudes of the employees. It was developed earlier that social conditions of employees are also a notable factor of how CSR activities can affect their attitudes. Therefore, it would be interesting to study the connection between CSR perceptions of employees across organisation hierarchies in the future.

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Performance Evaluation of Paddy Rice Pneumatic Dryer

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Abstract

This research was carried out to study the drying of paddy rice by using the developed pneumatic dryer with and without the outlet air cyclone installation on the dryer. In this study, Thai jasmine rice 105 variety was selected as a sample in the experiment. The characteristic of drying behavior, specific energy consumption (SEC), drying rate (DR) and percent of head rice yield were evaluated as the performance of dryer. For the drying experiments, a 40 kg of paddy rice was dried by the hot air temperature of 80° C with the proper of a terminal air velocity for paddy rice. The result shown that the drying system without cyclone gives a higher rate of moisture extraction than the system with cyclone installation. Based only on energy utilization during the process, the highest SEC of 7.25 MJ/kg_{water} occurs on the drying at the airflow rate of 0.0512 m³/s by without cyclone. For the dried product quality, the highest head rice yield of 36.84% on the drying at airflow rate of 0.0631 m³/s. The breakeven point of the developed dryer is 1.6 ton/year of a paddy rice drying.

Keywords: Paddy rice, pneumatic dryer, drying, head rice yield

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Introduction

Rice is a kind of grain, which is a staple food in Thailand and Asia such as China, Japan and Malaysia. After the paddy harvesting, the moisture content (MC) in a paddy rice is height especially in a rainy season and it can cause the low quality of rice after the milling process. Therefore, the moisture reduction in paddy rice is a very important post-harvest process and the right moisture content of paddy rice for a long storage life is around 14%db (dry basis) [1]. At this moisture, the rice after milled are less in grain damage and high in head rice yield percentage. There are many methods to reduce the moisture of paddy. In Thailand, the traditional way is sun drying. This naturally method is easy and save the cost of heat energy. However, this way has a localization because the problems of labor and drying area intensive, long drying period, seasons and cannot control the final moisture content of the paddy rice. Another method to reduce the moisture of paddy rice is using of the dryer. It is a favorite method because it can operate in year round, faster than sun drying and able to control the desired paddy moisture. Notwithstanding the advantage of the dryer, the energy consume, drying capacity and the rice quality is a major problems in the moisture reduction by the dryer. There are a lot of currently research about how to reduce the moisture of paddy and also develop the system of dryer machines in order to use low energy consume but give a high capacity such as developing solar air heaters by modifying the roof of building [2], using stream dryers [3], designing inclined bed dryers [4] and using spouted bed [5].

The well known artificial drying for the paddy rice are LSU and fluidized bed dryer. They can reduce moisture by the less time, high capacity and have a well moisture distribution in paddy. There have been attempts to develop LSU and fluidized bed dryers with other drying techniques such as using Far-infrared (FIR) [6] to reduce moisture and using hot air and superheated steam for drying system [7], However, both LSU and fluidized bed still use relatively high energy when compared to other drying systems. Therefore, pneumatic dryers are the interest technique to researcher because the dryers can be operated with low hot air temperature and have low initial cost.

Accordingly, this research aim to evaluate the performance of pneumatic dryer, quality of milled rice after drying and discover the appropriate operating condition of the dryer. In the future, the result of this study will use as a guideline for the application of efficiently drying energy.

Experimental detail and methods

The developed pneumatic dryer shown in figure 1. The paddy rice was contained within the bin (No.2) with a dimension of 500 mm (W) x 400 mm (L) x 800 mm (H). The drying process begins by the feed auger (No.5) at the bottom of the bin conveyed the paddy rice to the drying column (No.1) that was made from an acrylic cylinder with a diameter of 76 mm and 1,000 mm in height. At the same time, the 80° C of hot air produced by 3 kW of electric heater (No.3) charged to the drying column (No. 1) by the 3 HP of air blower and carried the paddy grains by the terminal velocity of the air. The moisture from paddy grain was removed by the hot air during paddy grainhot air mixing and blow pass the drying column. Finally, the mixer flow into the

cyclone (No.6) to separate the dried paddy and send it to the bin. This process continue circulatory runs until the paddy rice was dried.



Figure 1. (a) The developed pneumatic dryer (b) the paddy bin wall.

Testing in this experiment, Thai jasmine rice 105 variety was used to be the samples. For the drying experiment, a 40 kg of paddy was dried at 80°C of hot air drying temperature. The air volume flow rate and their related paddy feed rate were varied to 3 levels (set by the frequency on the blower motor invertor). The effect of cyclone installation are compared investigation. The drying behavior, specific energy consumption (SEC) by eq.1 (in MJ/kg_{water}), drying rate (DR) by eq.2 (in kg_{water}/hr) and percent of head rice yield (%) by eq.3 were evaluated as the performance.

$$SEC = \frac{Q_A}{(W_i - W_f)}$$
(1)
Where SEC = Specific Energy Consumption (MJ/kg_{water})
 Q_A = Apply electric energy (MJ)
 W_i = Initial weight of paddy (kg)
 W_f = Final weight of paddy (kg)
 $DR = \frac{(W_i - W_f)}{hr}$
(2)
Where DR = Drying Rate (kg_{water}/hr)
hr = Drying time (hr)
Percent of head rice yield = $\frac{\text{weight of only full grain rice (kg)}}{\text{weight of paddy rice (kg)}} \times 100$
(3)

Results and Discussions

The drying behavior.

At the airflow rate of $0.0512 \text{ m}^3/\text{s}$, the system without cyclone uses a 377 minutes (around 6 hours) in the drying period. It is the fastest times in the moisture reducing from initial paddy rice to the finishing of moisture at around 14%wb (Table 1.). For

the system with cyclone, the results showed that the airflow rate of $0.0631 \text{ m}^3/\text{s}$ gives a fastest time in the reducing of moisture content of paddy rice. It uses a 486 minutes (around 8 hours) in drying time (Table 1.). Therefore, the drying by pneumatic dryer without the cyclone installed on the system can reduce the moisture of paddy rice faster than the system with cyclone.

Flow rate level	Air flow rate (m ³ /s)	Paddy feed rate (kg/min)	Condition	Initial paddy MC (%wb)	Final paddy MC (%wb)	Drying time (min)
			With	32.89 ± 0.13	13.88 ±	579.50
1	0.0451	4.10	cyclone		5.19	
1	0.0431	4.10	Without	32.96 ± 0.39	13.96 ±	446.50
			cyclone		6.28	
		6 35	With	33.21 ± 0.07	14.00 ± 5.47	565.50
2	0.0512		cyclone			
2	0.0312	0.55	Without	33.68 ± 0.06	14.06 ±	377.00
			cyclone		6.60	
			With	33.09 ± 0.65	14.00 ± 5.91	486.00
2	0.0621	8.45	cyclone			
5	0.0051		Without	32.88 ± 0.03	13.86 ±	409.50
			cyclone		6.61	

Table 1. The result of a pneumatic dryer without cyclone.

From both conditions, it was coincided that high airflow rates can well reduce moisture content of paddy rice because it generates the turbulence flow in the drying column. This situation leads the paddy rice well diffused within the hot air too and cause the high moisture extraction together and the drying behavior were shown in figure 2.



(a)



Figure 2. Behavior of paddy drying system (a) with cyclone (b) without cyclone

Specific energy consumption

In Figure 3, the results of the specific energy consumption of pneumatic dryer without cyclone showed that the airflow rate of $0.0512 \text{ m}^3/\text{s}$ yielded the best specific energy consumption (7.25 MJ / kg water). For the dryer system with cyclone, it was found that the airflow rate of $0.0631 \text{ m}^3/\text{s}$ have the best specific energy consumption (10.41 MJ/kgwater).

Drying Rates

The drying rates of the pneumatic dryer without cyclone showed that the airflow rate of 0.0512 m³/s generated the best drying rate (1.10 kg_{water}/hr) (Figure 3). For the dryer system with cyclone, it was found that the airflow rate of 0.0631 m³/s yielded better drying rate (0.82 kg_{water}/hr).

From the results, the pneumatic dryer without cyclone provided the better drying rates than those of the dryer with cyclone. Because after the drying process in the drying column, it can make a secondary drying on the surface of paddy rice in the bin during the hot air from drying column was released to the bin with paddy rice.



Figure 2. Comparison of specific energy consumption by cyclone and without cyclone installation.





Head rice yield

The percent of head rice yield was used as a quality index of dried paddy rice (Figure 4). However, because the long experiment time (30 days in overall experiments), the quality of paddy rice sample must decrease and take an effect to the percent of head rice yield too. For the system with the cyclone, the higher airflow rate level might reduce the head rice yield of paddy because the high speed of airflow can make more damage on the paddy too. Especially when the paddy rice hits to the cyclone in the system with cyclone. It was found that the airflow rate of 0.0451 m³/s yielded better head rice yield percentage of 33.91%.

For the system without cyclone, the higher airflow rate level might increases the head rice yield of paddy because the shortest time in drying and it have no mechanical damage by the cyclone and the airflow rate of 0.0631 m^3 /s generated the best head rice yield of 36.84%



Figure 4. Comparison of head rice yield by sun drying, cyclone and without cyclone installation.

Conclusion

The drying system without cyclone gives a higher rate of moisture extraction than the system with cyclone installation. Based only on energy utilization during the process, the highest SEC of 7.25 MJ/kg_{water} occurs on the drying at the airflow rate of 0.0512 m^3 /s by without cyclone. For the dried product quality, the highest head rice yield of

36.84% on the drying at airflow rate of 0.0631 m^3 /s. The breakeven point of the developed dryer is 1.6 ton/year of a paddy rice drying.

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Threat of Bio-Cultural Diversity Loss Evaluated by International Students; Case of Traditional Japanese Paper (Washi) Making in Futamata Community of Kanazawa City

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Abstract

Kanazawa City was designated as UNESCO Creative City in the field of crafts and folk, and the demand to the locally made traditional crafts still remains high in the city. However, after the rapid economical growth, the utilization of the local natural resource for traditional crafts making was reduced due to the introduction of the cheap materials from China. Traditional Japanese paper or Washi, remained one of the important bio-cultural elements that still use the local natural resources for its production and its production is managed in the sustainable manner with less negative impact to the environment.

We have conducted the educational field trips into the local Japanese community named Futamata in Mount Iozen region of Kanazawa City, Ishikawa Prefecture. The region is famous for making washi during the centuries, however due to the depopulation and aging problems now only three craftsmen have remained in the community. The culture faces the threat to be lost with no followers. 20 international students visited the fields and made their evaluations about the bio-cultural linkage, and gave some recommendations for the sustainable traditional crafts making. The outcomes of the field trips showed, that biological and cultural diversity were rich in the region, but, the sustainable practice of washi making cannot survive unless the bottom-up approach of the local authorities for its preservations.

Keywords: Bio-cultural conservation, Sustainable development, Regional education

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Introduction

Bio-cultural diversity is the term applied to the diverse network between the nature and human culture, that are "inextricably linked" to each other. Urbanized societies have very week perception of this link because of the weak direct dependence on nature. However, the awareness of the link remains strong in the rural communities, who plays key role in maintenance entire social identity (Maffi & Woodley, 2012). It is well known that most of the ecosystems of the cities are obtained from the rural areas, and it will be crucial to consider both areas, for the sustainable development. However, rural areas, are facing the major challenges of the environmental (natural and cultural) loss due to the aging and declining population, environmental changes, economic instability and others. Kanazawa City was chosen as the destination for our research, due to the rich culture of the city which is inextricably linked with the diverse ecosystems of the rural and suburb regions of the city. The population of the city is 450,000 people, and it is mid-size city with rich biological and cultural diversity. Due to its abundant culture, in 2009, the city was designated as a UNESCO Creative City in the field of crafts and folk. Currently city has designated 22 major crafts as representative traditional crafts of Kanazawa City. The city promotes the craft related industries in different angles and increases the craft-related budgets by implementing the cultural policies. Besides, the city develops its economy with preservation its environment (ecology) and ecosystem services, thereby stabilizing its economy with traditional and modern culture. Craftwork and handwork, do not requires the utilization of the fossil fuels, those this traditional culture strongly contributes for the sustainable environmental development of the city.

Futamata is a small town in mountainous area of Kanazawa City. The entire population is 377 people with 122 houses. The town is situated in the junction of two rivers with the small plateaus along the river sides. This natural environment is very suitable for making the paddy rice fields and for fishing, which is still practiced by the locals. Mainly the town is famous for the production of the traditional Japanese paper (washi), which is designated as one of the traditional crafts of Kanazawa City. Due to the abundant water flows and favorable natural conditions, the region for the centuries was practicing the paper making and it was named as *Futamata Washi*. Washi making was very demandable by local authorities and by the Buddhist monks for writing the Buddhist scriptures, and for their valuable qualities paper making practice was closely protected by the lord of Kaga feudal clan, Maeda Toshie since 1593. During those days, washi making was practiced in more than 100 houses, and only 10-15 people were making papers only for the lords. However, from the beginning of 20 century, due to the introduction of the western paper, the demand for the production of local Washi making started to decrease, and local people shifted into the agriculture and farming lifestyles (Nishimizu, 1993, in Japanese). After World War II, with the rapid economic growth, the utilization of the local natural resource for traditional crafts making was reduced due to the introduction of the cheap materials from China and many villagers started to leave to the city center for the stable income. Now in Futamata, there are only three washi making artists remained, two of whom are around their 70th. The annual production value of washi is 13 million yen. Kanazawa City has added the Futamata Washi to the list of the rare traditional craft, and its products are sold at the Kanazawa Crafts Hirosaka Shop, which is situated at the city center which is the main tourist destinations. Futamata Washi is used in many

traditional arts, calligraphy, woodblock printing, manufacture clothing and household goods.

The traditional paper making has lots of differences from the modern paper manufacturing. Modern companies that produce paper, plant enormous amount of trees which takes more than 10 years to grow (Ates et al., 2008). Moreover, the chemicals used in paper manufacturing also harm the environment when they are released into the water supplies and the land (Pokhrel, 2004). Besides, paper making industry have been changed over time due to technology and mass production. Paper making which was considered as hand-made craft, became automated over the time by using the machines. In contrast, to make Futamata Washi, there is no need to use big threes, but rather shrubs such as paper mulberry brush, kozo (Broussonetia papyrifera), oriental paper brush, mitsumata (Edgeworthia chrysantha) and Japanese shrub, ganpi (Wikstroemia sikokiana) are collected and the paper is crafted by hand (Figure 1). Kozo has long, strong fibers and is the most commonly used fibers for making washi in wide variety of applications, such as table paper, writing paper, shouji paper (Taylor, 2006). Kozo shrubs can be cultivated easily and can be harvested every year, with less time spend for their growth. Each process of washi making performed by hand, without using any chemical or artificial agents, and each parts of the fibers are used without waste (Figure 2 and Figure 3). This kind of paper making makes the process to be very sustainable in terms of time, cost and have less environmental impacts. However, in whole Japan the production of local vegetation's are decreasing rapidly, together with the decreased demand for washi, and no followers.





Figure 1. Kozo (on the left) and Mitsumata (rignt) shrubs growing in front of the house of paper making artist



Figure 2. Dried parts of Kozo



Figure 3. Futamata Washi

In this study we decided to evaluate how sustainable is the washi making process, and why there are so many obstacle for its continuation. International students were chosen to participate in our study, as for many local students the traditional crafts became a common sense, and their ability to evaluate the values and appreciation of it is less, compare to the international students. International students, when they are exposed into the unknown and new environmental conditions or culture, which differ from their own (Aida & Iida, 2016), have shown a big interest and high evaluation skills. International students were asked to find the linkage between biological and cultural diversity and evaluate how this linkage is important for the sustainable development.

Methodology of the course

During the summer period of the academic year 2016, between the beginning of June and the end of August, intensive teaching activities were carried oud, including inclass and fieldtrips activates organized by Kanazawa University. In total four field trips were carried out, which lasted for one or a half days. The number of the participants were academic 20 students with different study backgrounds. All trips were issue-oriented and guided by the professional local instructors, who gave the descriptions about the Futamata town, crafts that are produced in the city, depopulation problems and environmental issues. Later, students visited the houses of two artist (Artist "S" and Artist "T"), and made the comparative analysis between their practice and lifestyle. At the end, they visited the Hirosaka Shop at the city center of Kanazawa city, where their art are put on sell, and attracted by tourist.

Students were asked to find the elements that make washi making sustainable and consider how paper making can support and sustain the bio-cultural diversity of the community. Students submitted the reports were they indicated more than five sustainable elements and the risk factors that halt the sustainable practice. After each fieldtrip students were given the time to think and analyze, and provide the recommendations for the preservation of the traditional culture. Also, before and after the trips we conducted the survey, to find the students' awareness and knowledge about the bio-cultural linkage. Awareness and knowledge were scored by 1=Very Bad, 2=Bad, 3= Good, 4=Very Good.

Results

Before the fieldtrips almost most of the students showed that they had very low level of awareness about the bio-cultural linkage (85%). However, after the fieldtrips 90% replied that they became more aware about the existence of the bio-cultural linkage. Sustainable elements and issues related to the washi making were evaluated by the students. The results of the evaluating are shown in the Table 1.

issues faced with its manufacturing.	
Sustainable Elements	Issues
- Utilization of local ingredients	- Less demandable
- Less environmental impact	- Low income
- Easily grown fibers	- Time consuming
- Less equipment cost	- No automatization in manufacturing
- No need for advanced technologies	- No followers
- No waste products	- Requires physical labor
- Seasonal Practice (mainly winter)	- Expensive than the usual paper
- Local appreciation and trust	- Less local customers
- Support the traditional culture	- Less opportunities in the foreign
- Utilization in multi purposes	market
- High quality paper	- No daily life utilization
- Sustain the nature	
- More local customers	
- Less utility cost	

Table 1. Student's evaluation of the sustainable practice of washi making and the issues faced with its manufacturing.

90% of students reported that the washi making process is sustainable, however 75% reported that the practice would not last for other several decades. By interweaving the washi making artists, students found that even the Kanazawa City is trying to increase awareness about the importance of washi making by organizing the annual paper making events in Futamata, the annual number of participants are decreasing every year.

Also, students found the big difference between the paper making practice of Artist S and Artist I, which is shown in Table 2.

Table 2.	Comparison	made by s	students ł	between tw	o washi	making a	rtists.

Artist "S"	Artist "I"
- Age 73 years old, male	- Age 40 years old, female
- Local resident	- Renter of the atelier
- Farming is main income	- Income solely on Paper making
- Practice only in winter	- Produce the paper annually
- Uses natural cold water in winter	- Cold the water with the refrigerators
- Dries the paper naturally outdoor	- Uses the heater to dry the paper
- Produce standard paper	- Produces highly artistic, modern paper
- Supported by family	- Works alone
- Paper is less demandable	- Paper is more demandable
- Owes the land to grow the fiber plants	- Rents the land

For the sustainable continuation of the local craft, students provide the recommendations shown in the Table 3.

Table 3. Recommendations provide by students for the sustainable continuation of washi making

Recommendations

- Create the small business with paper making to attract more youth
- Start the international export with Futamata Washi
- Make washi available for the reasonable price to be used in the daily life
- Promote the local market and increase the local demand
- Improve the access for the area, so the volunteers, students can help with the paper making
- Government involvement for the economic support of the artist
- Create more modern innovations
- Increase more Creative and Craft tourism
- Youth education and awareness raising
- Create the Workshops to acquire the new knowledges for improvements of washi making with the collaboration with other prefectures
- Make international exchange

Conclusion and Discussions

Paper making in Futamata have shown that even the practice is very sustainable in terms of production and environmental preservation, it cannot survive if there is no stable income and economic profits. All two artist confirmed that even thought that their paper are sold in the local shops, there is no stable customers and they cannot rely on the firm income. Second, as paper making by hand is highly time consuming process and requires hard labor, less youth are involved in its manufacturing. For the continuation of washi making, it was suggested by the students that the modern techniques must be used to increase the production amount, and reduce the labor work. Big differences of the paper making were found between two artists, which have shown that for the continuation of the practice the demand can be increased according to the modern requirements and innovations. Artist "I", is producing the washi annually and pays the high utility cost and land rent, however, her paper has more artistic qualities and is more demandable in the local market. Whereas the Artist "S", is the local farmer who doesn't rely only on paper making, but uses it as a second income after farming. He produces paper only during winter seasons, which cuts the utility cost, however the paper quality and type are standardized and the demand is less

Most of the international students showed that Futamata washi making, would not survive during the next few decades, if there is no serious measurements from the side of the government, small local and international business sectors. The loss of Futama washi, will lead to the loss of the regional identity, which was famous for paper making for centuries. After the fieldworks, international students were able to find the linkage of biological and cultural diversity, and see how this linkage is fragile if there is no human interaction. Concrete measurements should be taken to educate and train the successor, by implementing the exchange activities between the other craftsmen and make international collaboration.

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The Path Towards Sustainable Development

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Abstract

Development is the process of change in a current system for comfort. The outcome of development can be positive or negative. Only development concept has failed and produces damage to lives and its consequences are natural calamities and terrorism. So the whole world is searching for sustainable development. Religious values are a strong denominator against which all other values could be equated and is trusted instrument. Different religions advocates for Nature, Spirituality and sustainability. Hinduism contains numerous references to the worship of divine Nature in Vedas, Purans. Buddhism says for survival mankind has to depend on Nature for his shelter, food, clothing, medicine and other requisites. Buddhism teaches us love for Nature and nonviolence. Islam's Quran says that Allah is the creator of world. They are told to look after the world for Allah and for future. Christianity teaches us to spread love for Nature, Peace and nonviolence. It also teaches us to help poor people. According to the theory of Jainism, the five elements of Nature, Prathivi, Jal, Agni, Vayu and Akash are living creatures and must be treated as living beings. So every religion advocates for the protection of Nature natural elements and biodiversity conservation. Gandhiji said, "Earth provides enough to fulfill man's need but not man's greed." For sustainable development, reduce, reuse and recycle is the best concept. New social ethics should be inculcated among children both in school and at home emphasizing concern.

Keywords: Spirituality, Nonviolence, Natural elements, Denominator, Greed

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Introduction

Development is the process of change in current system comfort and luxury. However the outcome of development can be positive or negative. Positive are advance science and technology, advanced medical science, good infrastructure, and electronic goods.

Instead of this modern man in his search for pleasure and affluence has exploited Nature without any moral restrain to such an extent that Nature has been incapable of sustaining healthy life. Invaluable gifts of nature such as air, water, soil and sky have polluted with severely disastrous consequences.

Man is now searching for ways and means of overcoming the pollution because his health too is alarming threatened. So the Human kind wants development which can sustain and can protect the Nature. To overcome this problem and maintain balance between development and nature, the term sustainable development is coined. Hence sustainable development is defined as a pattern of development which fulfills human needs while taking in to consideration the factors regarding security and protection of environment, culture, moral and socio-religious values.

Now human being feels that it is irresponsible and morally wrong on his part to commit polluted planet to future generation. He is searching to find an appropriate environmental ethic to prevent further aggravation of the present pollution problem. He has forgotten wisdom of environmental values in the area of religion. Now human is realizing religious values are most effective on general public. In past, every culture and civilization, every religion used to be a strong denominator against which all other values could be equated. The religion is trusted instrument and has been used effectively to achieve socioeconomic, environmental and cultural targets.

Every religions advocates spiritual values, health, environment, non-materialism and nonviolence. Religion preaches us our duties and emphasize on maintaining balance between "Needs and Greed".

Thus today understanding about sustainable development is not a new concept but just a revised terminology which we all forgot once. Now we will note, how different religion talks about sustainable development".

We have tried to discuss view points of different religions and cultures in brief to focus on importance of choosing right path for "sustainable and holistic development".

Hinduism- It is oldest but most evolved, scientific religion. It contains ready references from Vedas, Purans, Upnishads to understand, Why Nature is called "Mother"? Hinduism teaches us that the five great elements (space, air, fire, water and earth) that constitute the environment are all derived from Prakrati. In Hinduism, Nature is called Prakrati.

Why we worship divine elements related to "Nature". Millions of Hindus recite Sanskrit mantras daily to revere their rivers, mountains, trees, animals and the Earth. This Religion preaches us our duty between Needs and Greed's.

The Chipko (tree hugging) movement is the most widely known example of Hindu environment leadership. In Hindu mythology the five elements which create life are air, water, fire, earth and space. These five elements derived from "Prakrati". Hindu religious books guide us that every element of Nature should be respected and should not pollute. If not taken care "Mother Nature" may result into devastating curse from respective deities leading to Natural calamities like flood, drought, Psunami and chakrabat (earth quakes).

The scientific facts Hindu culture walks closely holding and bridging ties between culture, nature and technology.

Naturopathy and Ayurveda is example of this symbiotic relationship between uses of Nature in healing process. Cutting down green trees like Banyan and Peepal is a strong sin in Hindu mythology. River is considered Mother and holy religious ceremony takes place on river bank from birth to death.

Hinduism and its off-shoots like Sikhism, Buddhism and Jainism are all based on same school of thoughts. The Jainism is an extreme example of belief on the theories of non-violence and truth.

Buddhism- In Buddhist culture and belief system there are following characteristic theories which are based on principles of

- 1. Simple and moderate life style.
- 2. Satisfaction of basic human necessities.
- 3. Reduction of wants to the minimum frugality.

It is only possible when whole mankind adopt a simple and moderate lifestyle. Whole mankind adopts a simple and moderate life style. Whole mankind will stop to polluting the environment. This seems to be the only way of over-coming the present eco-crisis and problem of alienation. With such life style, man will adopt a non-exploitative, non-aggressive, gentle attitude towards Nature. He can than live in harmony with Nature utilizing its resources for the satisfaction of basic needs. Our planet is very beautiful. Its life is ours life and its future is ours future. Earth nourishes us just like Mother. We, like children are dependent on her. So the global problems cannot be solved by a single Nation. All nation of the Earth, should work together to protect nature. Our Mother Earth is teaching us a lesson of universal responsibility. Buddhism always preaches us the virtues of non-greed, non-hatred and non-delusion in all human pursuits. Greed breeds sorrow spoils Nature and unhealthy consequences. Buddhism advocates a gentle non-aggressive attitude towards "Nature".

Jainism- is one of the most environmentally conscious religion in the world. The religion is based on the principles of nonviolence all living beings and Nature.

Sikhism- In Sikhism, environment is part of an integrated approach to life and Nature. As all creation has the same origin and end. Humans must have consciousness of their place in creation and their relationship with the rest of creation.

Islamism- It also give due respect and importance to natural elements. Islam teaches us that all creation of God whether it is tiny aunt or huge lion serves a certain purpose in the larger scheme of God's world. "There is not an animal(that lives on the earth or a being that flies on its wings, but form part of communities like you."(Quran6:38). Allah reminds us in Quran not to temper with his divine balance.

Main trustee and vicegerent- The following Quran verses emphasize the point "Believe in Allah and his messenger and spend of that where of he hath made you trustees and such of you as believe and spend (a right) there will be a reward. (Quran 57:7). So we are mere trustees of the wealth in our possession.

For environmental crisis, Quran call us to recognize our own contribution to the crisis. The sanctity of planting trees- Prophet Mohammad said that if one plants a tree then whatever is eventually eaten from it by humans, animals counts for the planter as an act of charity.

Equilibrium of all lives- Muslims believe that all creation of Allah including animals, trees glorify God (Allah) in their way and bow down in worship all things that are in the heavens and on the Earth, Sun, Moon, Stars, Hills, Trees, Animals and Mankind. (Quran 22: 18). Allah reminds us in the Quran, not to temper this divine balance (measure). In Quran, "The sky he hath uplifted and He hath set the divine balance, not to destroy divine balance but measure strictly, nor fall short there of." (55:7-9). Hence, irresponsible deforestation and wanton killing of even the tiniest of God's creature is strongly discouraged in Islam.

Conservation- Wastefulness is a major contributing factor to our present woes. So in life, reduce, reuse and recycling should be the moto in the modern time. The Quranic caution, "But waste not by excess: for Allah love not the wasters." The principle of conservation is illustrated by the following rule, Islamic act of worship: while making ablutions in the preparation for prayer, use minimum water. Muslims following this rule is must, due to conservation of water and other natural resources as divine provisions.

The Quran calls us to recognize our own contribution to the crisis. " corruption doth appear on land and sea because of (the evil) which men's hands have done, that he may make them taste apart of that which they have done, in order they may return. (Quran: 30: 41). Due to deterioration of our environment and our natural resources, we need to do our best to restore, preserve and conserve the balance in Nature. Allah has appointed us as viceroys and trustees of Earth planet. So it is our responsibility to save and flourish the planet. We can do some efforts. Reduce, Reuse and Recycle should be the main theme of

living style. For reforestation, plantation should be encouraged at high level. We should conserve and should not pollute the natural resources such as water, air, land and sky.

Chrishtianism- Christianity has a long tradition of reflection on Nature and human responsibility. Christian environmentalist opposes policies and practices that threaten the health or survival of the planet. According to Bible, human is keeper, we are called "Steward of the Earth". There are three principles—We all live on the same planet and ultimately dependent on natural fruits of earth for the life support. So every individual person should take care of nature and its elements.

1. God created world and therefore values all his works for creation(Principle of creation value).

2. God created and sustain all elements and systems in his creation within practical order to meet certain outgoing purposes.(Principle of sustain of order and purpose).

3. Everything in the created world and universe is subject to corruption by sin and ultimate redemption through Jesus Christ. (Principle of universal corruption and redemption).

According the direction of holy books (keep in Middle) country policy makers should emphasis the following strategies for sustainable development.

The concept of sustainable development gives the new direction of resource conservation strategies which are:

- 1. Conservation or reduction of excessive resource use.
- 2. Recycling and reuse of material.
- 3. More use of renewable resources like Solar, Air and Water energy rather than non-renewable resources such as oil and coal.

Sustainable development requires fulfilling basic needs for all people of the world not luxury for some people. Ecological interest of the whole world is same eg effects of pesticides, insecticides, fertilizers and irrigation practices are common in every country. One country should share to another country.

For sustainable development in the world, we require policy changes at the global level . The key points of all religion about conservation, environment, moral and spiritual from east to west should combine (keep in middle) than policy makers innovate and discover the new policies for sustainable development.

There are some obstacles in the path of sustainable development.

- 1. High technology
- 2. Non conservation
- 3. Deforestation
- 4. Population
- 5. Economic policy

Instead of these obstacles, we should follow the

- 1. Appropriate technology
- 2. Conservation
- 3. Reforestation
- 4. Space ship economy

Characteristic feature of appropriate technology

- 1. Small to medium sized are used, which maximize human output.
- 2. Technology is simple and easy to understand.
- 3. Employees do a variety of tasks resulting in increased output.
- 4. It is less capital intensive and maintenance is easy.
- 5. Local resources are used, products are mainly created for local use. leading to self sufficiency.
- 6. Decentralized production and control and small amount of pollution.
- 7. It emphasis the use of natural biodegradable material.
- 8. Small amount of energy and material input and small amount of pollution.
- 9. The use of renewable energy resources emphasized.
- 10. Compatible with local culture and the environment.
- 11. It encourages local talents and handicrafts and the products are durable.

New global economic system

Appropriate technology is advantageous and is boon. It increases happiness, health and satisfaction, it gives employment and should reduce corruption and crime. Some economist believe that new economic system at global level is necessary for long term survival of the human race.

On contrary, the present economic growth system is indexed by maximum flow of money, maximum production, maximum consumption, maximum resource use and maximum profit.

The **frontier economy** should be replaced by **spaceship economy** which says that earth like a spaceship is a closed system. Spaceship economy or a sustainable economy promotes recycling, reuse and reduce. It emphasize on conservative use of renewable resources, product durability and a clean and healthy environment. Broken goods should repair rather than replaced. Harmful non degradable wastes would be eliminated as much as possible.

In future, patterns of developments should be based less on materialism. There should be some common and major goals that developed and developing nations need to set to achieve a sustainable economy.

Conservation—For sustainable development basis, earth's natural resources must be used smartly to enhance their utility without prejudice. The solar energy, wind energy

and water energy can help us to maximize the benefits with minimum damage to natural resources.

Population--- UNO has warned the countries about population growth. For achieving goals of sustainable development, the population growth should be controlled.

Here I want to relook at the definition of developed and un-developed countries. The countries involved in polluting ecosystem in name of Science and Technology for their own comfort and luxury and to raise living standard. Similarly those countries who exploit environment to develop arms and advanced weapons can not be graded as developed countries. Ranther, those countries which are eco-friendly, happy, healthy and where basic living needs are satisfied and economy is stable. Those who live with peace and harmony with human kind and nature are real developed countries.

To achieve path of sustainable development we must have to think about pollution free and green planet for generation. Countries have to invest on long term futuristic goals and develop policies likewise keeping in mind the real meaning of development.

In search of wisdom and knowledge, human have discovered the path of religion which can enlighten mankind towards new attitude, culture and society. It would be best to follow popular **Buddha's Middle-path** concept which means balanced growth.

Thank-you.

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