ACSEE2019

& INDEPENDENCE INTERDEPENDENCE

Official Conference Proceedings

ISSN: 2186-2311

Organised by The International Academic Forum (IAFOR) in association with the IAFOR Research Centre at Osaka University and IAFOR's Global University Partners

May 20–22, 2019 | TOKYO, JAPAN

"To Open Minds, To Educate Intelligence, To Inform Decisions"

The International Academic Forum provides new perspectives to the thought-leaders and decision-makers of today and tomorrow by offering constructive environments for dialogue and interchange at the intersections of nation, culture, and discipline. Headquartered in Nagoya, Japan, and registered as a Non-Profit Organization (一般社団法人) , IAFOR is an independent think tank committed to the deeper understanding of contemporary geo-political transformation, particularly in the Asia Pacific Region.

INTERNATIONAL

INTERCULTURAL

INTERDISCIPLINARY

iafor

The Executive Council of the International Advisory Board

Mr Mitsumasa Aoyama
Director, The Yufuku Gallery, Tokyo, Japan

Lord Charles Bruce
Lord Lieutenant of Fife
Chairman of the Patrons of the National Galleries of Scotland
Trustee of the Historic Scotland Foundation, UK

Professor Donald E. Hall
Herbert J. and Ann L. Siegel Dean
Lehigh University, USA
Former Jackson Distinguished Professor of English and Chair of the Department of English

Professor Arthur Stockwin
Founding Director of the Nissan Institute for Japanese Studies & Emeritus Professor
The University of Oxford UK

Professor Chung-Ying Cheng
Professor of Philosophy, University of Hawai'i at Manoa, USA
Editor-in-Chief, The Journal of Chinese Philosophy

Professor Steve Cornwell
Professor of English and Interdisciplinary Studies, Osaka Jogakuin University, Osaka, Japan
Osaka Local Conference Chair

Professor A. Robert Lee
Former Professor of English at Nihon University, Tokyo from 1997 to 2011, previously long taught at the University of Kent at Canterbury, UK

Professor Dexter Da Silva
Professor of Educational Psychology, Keisen University, Tokyo, Japan

Professor Georges Depeyrot
Professor and Director of Research & Member of the Board of Trustees
French National Center for Scientific Research (CNRS) & L'Ecole Normale Superieure, Paris, France

Professor Johannes Moenius
William R. and S. Sue Johnson Endowed Chair of Spatial Economic Analysis and Regional Planning
The University of Redlands School of Business, USA

Professor June Henton
Dean, College of Human Sciences, Auburn University, USA

Professor Michael Hudson
President of The Institute for the Study of Long-Term Economic Trends (ISLET)
Distinguished Research Professor of Economics, The University of Missouri, Kansas City

Professor Koichi Iwabuchi
Professor of Media and Cultural Studies & Director of the Monash Asia Institute, Monash University, Australia

Professor Sue Jackson
Professor of Lifelong Learning and Gender & Pro-Vice Master of Teaching and Learning, Birkbeck, University of London, UK

Professor Sir Geoffrey Lloyd
Senior Scholar in Residence, The Needham Research Institute, Cambridge, UK
Fellow and Former Master, Darwin College, University of Cambridge
Fellow of the British Academy

Professor Keith Miller
Orthwein Endowed Professor for Lifelong Learning in the Science, University of Missouri-St.Louis, USA

Professor Kuniko Miyanaga
Director, Human Potential Institute, Japan
Fellow, Reischauer Institute, Harvard University, USA

Professor Dennis McInerney
Chair Professor of Educational Psychology and Co-Director of the Assessment Research Centre
The Hong Kong Institute of Education, Hong Kong SAR

Professor Brian Daizen Victoria
Professor of English
Fellow of the Oxford Centre for Buddhist Studies

Professor Michiko Nakano
Professor of English & Director of the Distance Learning Center, Waseda University, Tokyo, Japan

Professor Thomas Brian Mooney
Professor of Philosophy
Head of School of Creative Arts and Humanities
Professor of Philosophy and Head of School of Creative Arts and Humanities, Charles Darwin University, Australia

Professor Baden Offord
Professor of Cultural Studies and Human Rights & Co-Director of the Centre for Peace and Social Justice
Southern Cross University, Australia

Professor Frank S. Ravitch
Professor of Law & Walter H. Stowers Chair in Law and Religion, Michigan State University College of Law

Professor Richard Roth
Senior Associate Dean, Medill School of Journalism, Northwestern University, Qatar

Professor Monty P. Satiadarma
Clinical Psychologist and Lecturer in Psychology & Former Dean of the Department of Psychology and Rector of the University, Tarumanugara University, Indonesia

Mr Mohamed Salaheen
Director, The United Nations World Food Programme, Japan & Korea

Mr Lowell Sheppard
Asia Pacific Director, HOPE International Development Agency, Canada/Japan

His Excellency Dr Drago Stambuk
Croatian Ambassador to Brazil, Brazil

Professor Mary Stuart
Vice-Chancellor, The University of Lincoln, UK

Professor Gary Swanson
Distinguished Journalist-in-Residence & Mildred S. Hansen Endowed Chair, The University of Northern Colorado, USA

Professor Jiro Takai
Secretary General of the Asian Association for Social Psychology & Professor of Social Psychology
Graduate School of Education and Human Development, Nagoya University, Japan

Professor Svetlana Ter Minasova
President of the Faculty of Foreign Languages and Area Studies, Lomonosov Moscow State University

Professor Yozo Yokota
Director of the Center for Human Rights Affairs, Japan
Former UN Special Rapporteur on Myanmar

Professor Kensaku Yoshida
Professor of English & Director of the Center for the Teaching of Foreign Languages in General Education, Sophia University, Tokyo, Japan

The Asian Conference on Sustainability, Energy & the Environment 2019

Official Conference Proceedings

ISSN: 2186-2311

The International Academic Forum (IAFOR)
Sakae 1-16-26-201
Naka Ward, Nagoya, Aichi
Japan 460-0008
ww.iafor.org

Table of Contents

Exploring the "Self-flowing" Rural Living Water Model in Suzhong Water Network Area of China

Shi Hanyue, Southeast University, China
Huang Xiaoqing, Southeast University, China

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
The relationship between the "canal-frame-row-squat" water network system built by Zhang Jian in the Suzhong area of China 100 years ago is inseparable. However, the modern lifestyle and the construction of transportation facilities have caused structural damage, resulting in a sustained negative impact on the ecological environment. In recent years, governments have adopted measures such as increasing pumps to control them. However, such measures require higher costs and shorter live water hours, thus covering only rivers within the urban area, but have not been for more extensive villages. Efficient and ecological way of living water. The problem of water network problems in China's Central Jiangsu region is that the water is not smooth and the water speed is too slow. The author found three main reasons: First, the new road blocked the connection between the "row" and the "squat", resulting in multiple "end-waterways"; Secondly, the number of river channel nodes per unit length is too large, and the water flow is insufficient, so the river water flows slowly and is not oriented; finally, because the sediment in the river channel is freshly cleaned, the river bed is narrowed or even filled and disappeared. Based on its core problem, this study proposes a replicable "self-flowing" rural living water model consisting of "mutual" type living water units, and verified it through the case of Pingan Village, Haimen City, Jiangsu Province, China. Finally, the model is simulated by water flow using MIKE21 software to verify and optimize the model.

Keywords: Suzhong Self-flowing Water Model

iafor
The International Academic Forum
www.iafor.org

Background

Many of China's coastal and coastal cities are located in plain water network areas with low terrain and poor drainage conditions. The Suzhong Plain area is a typical case. Its water network is a typical tidal river network, which follows a strict "canal-frame-row-squat"order. The water network model is a valuable asset left by Zhang Wei's "Save the Country" 100 years ago. Under the basic framework of the Suzhong rural system, its life and production are inseparable from water. However, along with the gradual changes in rural life and production patterns, rural water environment governance has become a thorny issue that has to be faced at the moment. The study found that the water network is unreasonable and the water pollution is the crux of the water environment in the region. The fine trenches are intertwined with the living space of the residents, but almost all the trenches have become the end of the river, and the water flows in and out in the same direction, thus forming stagnant water at the end. In addition, domestic sewage is directly discharged into the river, the sewage is not purified, and agricultural pollution is infiltrated into the soil, which also causes pollution of water bodies.

In response to this ecological problem, the local government has taken certain measures to improve, such as the implementation of the "river system" policy, the regular water pollution control of the river, etc., but due to the large human and financial resources, it is only possible to the main river channel. Water quality is governed, and water quality in trenches and waterways that are more closely related to residents' lives cannot be purified. In addition to the large amount of water pollution caused by the river network itself, another important aspect is that the current measures are all external pollution cleaning methods, and as part of the ecosystem, the river network Its own ecological stability attributes have not been stimulated. Therefore, the author hopes that in this study, the river network can be based on its own characteristics, through a series of measures to enable it to achieve self-circulation and self-purification in the current human environment, so as to the entire Suzhong water network. Play a role in improving quality.

Case Study

Ruibei Village is located in the northeast of Desheng Town, Haimen City. It borders Tongzhou Dizhen Town in the north and is merged by five communities: Ping An, Tiandong, Dingxi, Dingxing and Ruibei. The area under the jurisdiction of the village is 6 square kilometers, and the village has 51 village groups. 1,620 households with a total population of 4,050. The village has an area of 4,247 mu of cultivated land and 210 mu of water. The roads in the village are 3 vertical and 3 horizontal, 10 east and west, 1 third-class river, 7 fourth-grade rivers, 58 gullies and 16 bridges. Among them, Ping An Community (Fig. 1) is located in the middle of Ruibei Village. It is the center of the village. Its water network is criss-crossed and is a typical form of water network in the Suzhong Plain. Since Zhang Wei led the implementation of the "Tong-hai-ken-mu" project, the Ping An community has always existed as an important gathering point for residents. The residents here maintain an intimate and harmonious relationship with the water system, but due to the construction of roads and the development of industry and agriculture, Ping An Village The water environment was destroyed and the waterway structure changed. Therefore, as a typical Suzhong water network, Pingan Village has typical water environment

problems. This study will focus on the reform of the area, and conduct in-depth research on its water environment issues and propose improvement measures to form a self-flowing new water network.

Fig. 1 Ping An Community

Through in-depth research and field investigation, the author summarizes the problems in the region as three aspects: the water is not smooth, the pollution source has not been treated, and the self-recovery needs to be improved. At the beginning of the high tide, the flow of the river flows from south to north. At this time, the flow of water flowing into the river and the gully is indefinite. In 1985, the main road was built, and the main channel was cut off, making the internal gully become the broken river. At this time, the gully has a fixed flow. Direction, the direction of the river is uncertain. Secondly, the sewage in the base mainly comes from domestic sewage and agricultural sewage, and domestic sewage is directly discharged into the ditch by household. Finally, after the main road in the village is cut off from the gully, the silt in the end gully gradually accumulates. In addition, the rainstorm will make the river bank mud in the middle of the river. The government uses the method of dredging mud to fill the river channel, resulting in a gradual reduction of the river channel area. We have further analyzed the status quo problem and found that the relationship between life and water network space has changed under the changing times, including the transformation of production methods, living space and cultural entertainment. With the development of society, the residents of Pingan Village have changed from paddy sanitation to leaving their hometowns to work in cities. Therefore, the labor force has gradually moved away from agriculture. At this time, the economic value of the water network that people used to live on has gradually decreased. At the same time, the living space was basically concentrated in farmland and river courses, and with the development of transportation, public life and activities were concentrated on both sides of the road, and the internal farmland was relatively private. In addition, the water network has spawned a variety of cultural and entertainment methods, but due to the development of information and water network pollution, the village entertainment has turned to indoor development. Secondly, after many interviews with the author, it was found that the local residents of Pingan Village missed the clean and amiable rivers in the old days and expressed their

willingness to participate in the remediation plan for the river water regeneration.

Living water strategy

This study starts from the source of local water pollution and takes "living water" as the main target. Based on the respect of the original three-level water system, the site is fully utilized to make full use of the characteristics of water flow lines and flow velocity, and proposes the "water network regeneration" combined with point and line. “Planning and coupling with the public space of the villagers to reshape the scene of “water and water pro” in the water town.

Based on the original pattern of the water network, this study proposed a “mutual” type living water unit. Relying on the existing water network, the scale of the living water unit is controlled by the kinetic calculation in the module of 400*400m (Fig. 2). The directional flow of water in the unit solves the problem of the current stagnant water. The division of the unit changed the original channel structure, and the trenches in the middle became a higher level of river channel, while the whole unit formed the last level of the river. This mode can be applied to the impact plains throughout the Suzhong to improve the existing water-free problem, thereby improving the self-purification capacity of the overall ecological environment. During the high tide, the river flows from south to north. Due to the difference in water potential energy, the water flow in the living water unit enters from the river, flows through the farmland and residential areas, and flows to the secondary trench to flow northward. At the time of low tide, the water body of the river exits from the north to the south, and the direction of the water flow is opposite to the direction of the high tide. Therefore, the water purification filter between the secondary trench and the living water unit plays a role.

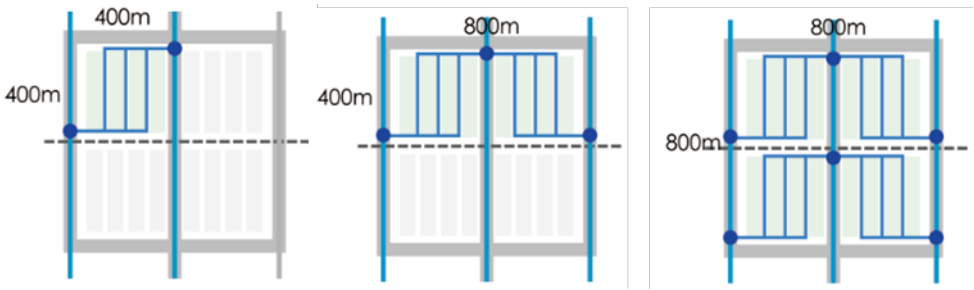


Fig. 2 “Mutual” type living water unit

Simulation

The river network is the main channel for river pollutants. The home of the River Grid Bureau is related to the migration and enrichment of river pollutants. From the perspective of pollutant transport, this study proposes four river grid bureau indices, through which these indices are Reflects the river's ability to discharge pollutants and self-purification. The number of nodes in the main river channel is P=N/S, that is, the length of the main channel divided by the number of rivers exchanged with the river, and the river tortuosity index Q=S1/S2, that is, the length of the channel divided by the line from the start point to the end of the river. The angle of the river channel is $\varphi=\arcsin[\alpha/10]$, α is the length of the vertical line from the intersection of the river channel to the main channel, the length of the sewage flow is $M=Ma+\sum Mi-1$, and M

is the height of the river basin where the sewage outlet is located. The level river crossing is at a distance from the estuary of the higher level river.

In this study, the MIKE11 software was used to simulate the hydrodynamics of the new water network. The annual average water velocity was used as the current water velocity of the river. The bottom of the river was calculated as the flat land, and the river width was averaged. The simulation results show that the current water velocity of the gully-grade river channel is about 0m/s (Fig. 3), which means that the current gully and the river water in the river channel are in the state of stagnant water. The water velocity of the gully-grade river channel of the modified "mutual" water network is 0.25m/s—0.35m/s (Fig. 4), and the water velocity is improved obviously.

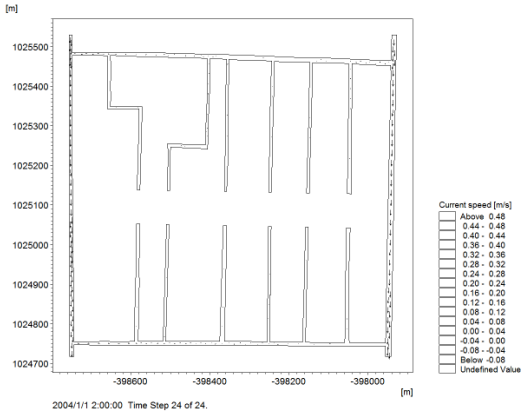


Fig. 3 the current water velocity

Fig. 4 the modified "mutual" water network's velocity

Conclusion

This study verified by software simulation that the "mutual" water network can effectively improve the self-purification capacity of the water network in the Suzhong Plain. In addition, the government, residents, tourists and investors will build a family farm with demonstration functions and expand Its social impact and social benefits, and finally hope to use this as a pilot, using its modular, reproducible characteristics, to expand into the rural areas of the Soviet Union, to form a rural area of water and surplus, and water and neighbors.

For the time being, most of the water quality in the Suzhong Plain has been polluted.

In a few areas, the river water is black and smelly, and the self-cleaning function of the river has been basically lost. Through the implementation of self-flowing water network improvement measures, combined with the actual situation of water ecology in Suzhong, a new comprehensive water environment management to protect “water ecology”, improve “water quality”, enrich “water landscape” and develop “water economy” Road, so that water resources can play the greatest economic, social and environmental benefits. The specific requirements are to achieve four adherences, namely: adhere to the combination of water environment management and water pollution prevention and control - improve "water quality", adhere to the combination of water environment management and sustainable development of water resources - protect "water ecology" and adhere to water environment management Combine with regional culture - enrich the "water culture", adhere to the combination of water environment governance and economic development - develop "water economy". Pay attention to the combination of water environment management and economic development mode, structural transformation and upgrading, and eliminate a number of high-pollution, high-energy, low-output enterprises through the guidance and reversal mechanism, and foster the development of low-energy, low-pollution, high-value-added green industries. Vigorously develop the tertiary industry, through the improvement of water ecology, beautification of water landscape, and promotion of water culture, so that various water environment elements can be organically combined with landscaping, leisure tourism, etc. In the near future, a "water clear, shore green, scenery beautiful" - Suzhong will definitely arrive.

Acknowledgements

This study would not have been possible without the consistent valuable reference materials that I received from my teammates， whose insightful guidance and enthusiastic encouragement in the course of shaping my paper definitely gain my deepest gratitude.

References

Xia Jun, & Liu Deping. (1995). Simulation of hydrology and water resources system in the water network area of Hubei Plain. *Journal of Hydraulic Engineering (11)*, 46-55.

Yang Mingsong. (2001). Study on urban drainage planning problems in plain water network areas. *Urban planning (9)*, 68-71.

Xu Haizhong, & Fang Yimei. (2014). Exploration of the method of regulating water body in plain water network--Taking the Shangtang River Basin in Haining as an example. *Low-carbon world (9)*.

Lu Wei, & Ying Conghui. (2014). Analysis of the effect of water diversion to improve river water quality. *People's Yangtze River (18)*, 37-39.

Taihu Basin Management Bureau of the Ministry of Water Resources, Jiangsu Provincial Department of Water Resources, & Jiangsu Provincial Department of Environmental Protection. (2007). Analysis of the effect of water diversion from the Yangtze River to improve the water quality of Taihu Lake. *China Water Conservancy (17)*.

Xiaojun Deng. Correlations between water quality and the structure and connectivity of the river network in the Southern Jiangsu Plain, Eastern China[J]. *Science of the Total Environment,2019*,664.

Contact email: 459552555@qq.com

Re-fragmentation of the Coral Echinopora lamellosa (Esper 1795) for Mariculture

Chou LM, National University of Singapore, Singapore
Toh TC, National University of Singapore, Singapore
Kikuzawa YP, National University of Singapore, Singapore
Loke HX, National University of Singapore, Singapore
Ng CSL, National University of Singapore, Singapore
Sam SQ, National University of Singapore, Singapore
Afiq-Rosli L, National University of Singapore, Singapore
Toh KB, National University of Singapore, Singapore
Taira D, National University of Singapore, Singapore
Poquita-Du RC, National University of Singapore, Singapore

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
Repeated fragmentation of corals can increase the source material to re-stock a coral nursery and reduce dependence on wild stocks. However, the efficacy of this approach to generate coral cover remains limited. Live tissue growth and dead area of *Echinopora lamellosa* fragments and re-fragments were measured at an *in situ* nursery over one year. Overall, re-fragmented *E. lamellosa* generated less live tissue area (n = 10, 116.1 ± 114.1 cm^2) than control fragments that were left intact (n = 20, 200.3 ± 130.9 cm^2). Re-fragmenting corals at sixth month of nursery rearing resulted in 23% loss of coral tissue and it required almost four months to attain the size before re-fragmentation. The increase in initial dead area significantly reduced coral growth in both treatments. The results for this species demonstrated that while re-fragmentation can increase the number of coral fragments, it is negated by the reduction in overall growth.

Keywords: Coral propagation, Ornamental trade, Reef restoration, Coral nurseries, Singapore.

iafor
The International Academic Forum
www.iafor.org

Introduction

The trade of live corals increased tenfold to approximately 650 tonnes from 1985 to 1997, comprising more than half of the global coral trade in 1997 (Green & Shirley, 1999). The rising popularity of the live coral trade has fuelled concerns that unregulated harvesting could pose irreversible damage to coral reefs (Smith & Hughes, 1999; Bruckner, 2000). However, recent advancements in coral culture and husbandry have helped to reduce an over-reliance on harvesting from the wild (Pomeroy et al. 2006). Coral mariculture, comprising sexual and asexual propagation methods, is increasingly carried out to supplement efforts to rehabilitate degraded reefs (Epstein et al. 2003; Toh et al. 2014; Ng et al. 2016) and enhance the ecological value of man-made structures in the marine environment (Ng et al. 2015; Toh et al. 2017).

Asexual propagation involves excising fragments off parent coral colonies, and rearing them in nurseries to obtain the desired quantity of coral materials (Bowden-Kerby, 2001; Ng et al. 2012). Compared to sexual propagation, this approach is widely adopted due to its low cost and relative ease of use (Rinkevich 2005). However, the availability of healthy donor colonies may be limited in degraded reef habitats (Edwards & Clark, 1999; Bruno & Selig, 2007; Lirman et al. 2010). Additionally, coral fragmentation causes tissue lesions along the fractured edges of parent colonies, rendering them more susceptible to colonisation by fouling organisms and infections from pathogens (Cumming, 2002; Titlyanov et al. 2005; Casey et al. 2015). This in turn creates dead areas on the coral fragments that hinders coral growth (Osinga et al. 2011; Leal et al. 2014).

To reduce the impacts on wild colonies, corals that are already being reared in nurseries could be re-fragmented for further cultivation and re-stocking. This strategy was useful in increasing the production of *Acropora palmata* (Forrester et al. 2013). However, the viability of this approach has not been extensively tested for other species. A one-year investigation at an *in situ* nursery was conducted to determine the feasibility of re-fragmenting nursery-grown *Echinopora lamellosa* to generate new coral propagules. The objectives were to (1) examine the influence of initial live tissue area and dead area on the growth of the nursery-reared corals and (2) compare the growth of live tissue between nursery-grown corals that had been re-fragmented in the sixth month of nursery-rearing with those that remained intact.

Materials and Methods

Study species and nursery rearing

Echinopora lamellosa (Esper, 1795) is a foliose scleractinian widely distributed across Indo-Pacific reefs (Veron, 2000) and it can dominate shallow reef areas by forming large assemblages (Sheppard, 1980; Dai, 1993; Veron, 2000). Fragments of *E. lamellosa* that had been transplanted grew rapidly despite the stresses arising from fragmentation and transplantation (Dizon & Yap, 2006; Shaish et al. 2008), suggesting the suitability of this species as a candidate for examining the effects of repeated fragmentation.

Ten *E. lamellosa* colonies (25–50 cm in diameter) were collected in August 2014 from a reef fringing Sultan Shoal (an offshore island southwest of Singapore;

1°14'22.86"N, 103°38'59.1"E) and transferred to an *in situ* coral nursery established off Lazarus Island (1°13'41.76"N, 103°51'19.82"E). The colonies were fragmented with hammer and chisel into 48 pieces of similar sizes (68.8 ± 19.7 cm^2). The fragments were then secured to six PVC-mesh fixed nursery tables (50 cm × 50 cm and elevated 40 cm above bottom substrate) that were deployed at 4–5 m depth of the reef. All fragments were placed at least 5 cm apart to minimise competition and overgrowth (Edwards & Gomez, 2007; Shafir et al. 2010). These fragments were reared for seven months from August 2014 (referred to as 'Phase 1').

Re-fragmentation of coral fragments

At the end of Phase 1 in March 2015, 30 fragments were randomly selected for the re-fragmentation experiment. Ten were re-fragmented into 20 halves (59.1 ± 24.6 cm^2; mean diameter ± s.d.) while the other 20 fragments were left intact as the control group (155.0 ± 38.8 cm^2; mean diameter ± s.d.) (referred to as 'Phase 2'). The 20 re-fragmented and 20 control fragments were reattached to 10 nursery tables and cultivated for six months (referred to as 'Phase 3'). The nursery tables were regularly maintained to remove accumulated sediment, fouling organisms (e.g. barnacles, sponges, tunicates, macroalgae) and corallivorous snails (*Drupella* spp.) throughout the study.

Data analysis

All fragments were monitored monthly throughout the study and *in situ* photographs were taken directly above the corals together with a scale bar. The live-tissue area and dead area of each coral were measured using the software ImageJ (Schneider et al. 2012).

Coral growth was defined as the change in live tissue area for each fragment relative to the initial live tissue area at the start of each monitoring period: 'Phase 1' (before re-fragmentation), 'Phase 2' (re-fragmentation), 'Phase 3' (after re-fragmentation), and 'Overall' (change in live tissue area over the entire duration of the study). Adapting the methods from Forrester et al. (2013) and Lohr et al. (2015), net coral growth was defined as the combined live tissue area of each pair of re-fragmented corals originating from the same colony (n = 10). The same calculation was done for the changes in dead area.

To investigate the influence of initial live tissue area and dead area on coral growth in Phase 1, the data were first tested for normality using Shapiro-Wilk test and homogeneity of variances using Levene's test, followed by linear regression. To examine the differences in live tissue area and dead area at each phase between treatments, data were tested for normality and homogeneity of variances. Subsequently, student *t*-tests were performed accordingly to test for significant differences in live tissue area and dead area between re-fragmented and control coral fragments. All statistical analyses were performed using SPSS version 17.0.

Results

Live tissue area

In Phase 1, growth was similar between corals in the re-fragmented and control groups ($p > 0.05$; Table 1), with corals in the former group growing from 64.4 ± 16.4 cm^2 to 135.1 ± 43.7 cm^2 (mean ± SD) and those in the latter group growing from 70.6

± 20.9 cm^2 to 150.5 ± 38.3 cm^2 (Figure 1a). The initial live tissue area was not a significant predictor of the change in live tissue area (Linear regression, $F = 0.025$, $p > 0.05$, $R^2 = 0.001$, Figure 2a).

Table 1. Change in mean live tissue area (LTA) and dead area (DA) of *Echinopora lamellosa* fragments in the re-fragmented treatment and control group. Standard deviations (SD) are shown in parentheses.

Treatment	n	Phase 1		Phase 2		Phase 3		Overall	
		LTA (cm^2)	DA (cm^2)	LTA (cm^2)	DA (cm^2)	LTA (cm^2)	DA (cm^2)	LTA (cm^2)	DA (cm^2)
Re-fragmented	10	70.7 (36.8)	15.0 (11.0)	-16.9 (27.5)	3.60 (5.17)	62.3 (99.4)	61.1 (31.9)	116.1 (114.1)	79.7 (35.4)
Control	20	79.9 (27.0)	16.1 (14.2)	4.45 (16.3)	1.77 (4.78)	115.9 (111.5)	47.2 (34.5)	200.3 (130.9)	65.1 (46.8)
t-value		-0.780	-0.22	-2.12	0.966	-1.29	1.06	-1.73	0.867
p-value		0.442	0.830	0.048*	0.342	0.209	0.297	0.0950	0.393

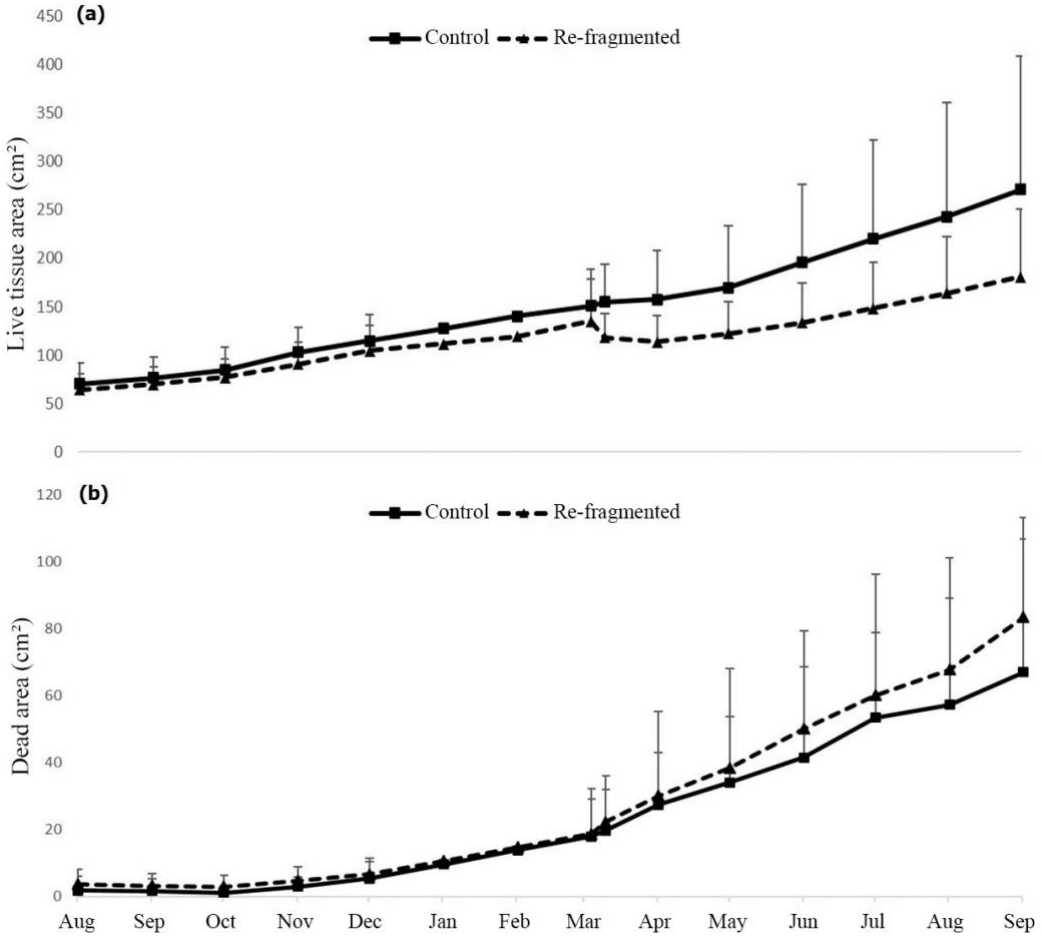


Figure 1. a) Mean live tissue area and b) dead area of *Echinopora lamellosa* fragments in the re-fragmented treatment (n = 10) and control group (n = 20) throughout the study (± SD). Re-fragmentation was carried out in March 2015.

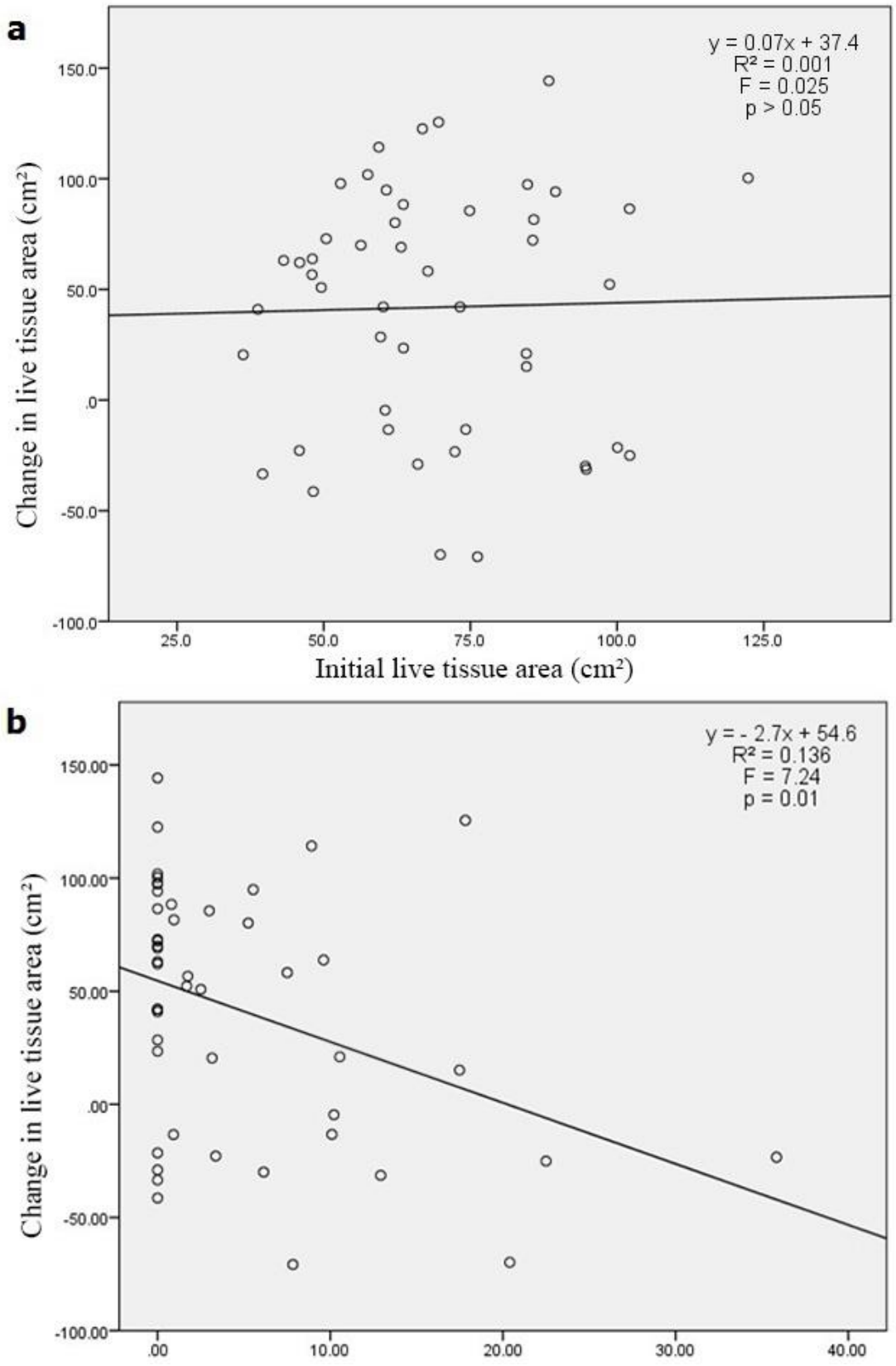


Figure 2. Linear regression predicting the change in live tissue area of *Echinopora lamellosa* fragments in Phase 1 using (a) initial live tissue area and (b) initial dead area (n = 48).

In Phase 2, corals in the re-fragmented group had significantly lower combined live tissue area than those in the control group (Table 1; $p < 0.05$). It took approximately four months for corals in the re-fragmented group (118.2 ± 41.3 cm^2) to attain a combined live tissue area of 133.3 ± 68.0 cm^2, a size that was similar to the corals prior to re-fragmentation (135.1 ± 43.7 cm^2) (Figure 1a).

The reduction in live tissue area of the corals upon re-fragmentation did not result in significant changes in growth throughout Phase 3 compared to corals in the control ($p = 0.209$) (Table 1). Overall, the re-fragmented corals were smaller (180.5 ± 112.6 cm^2) than those left intact (270.9 ± 137.8 cm^2; 1a) and coral growth in the re-fragmented treatment was 84.2 cm^2 lower than those in the control (Table 1; Figure 3).

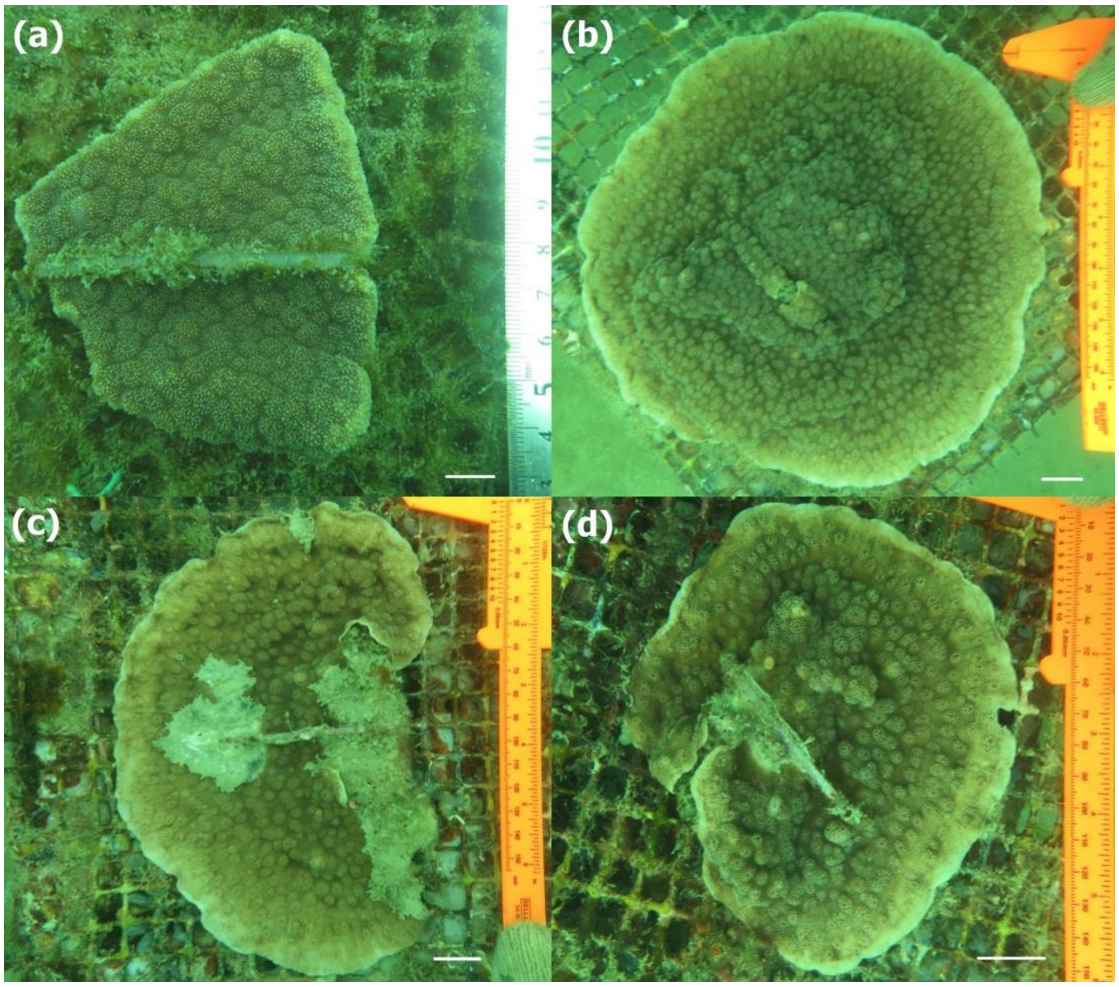


Figure 3. Representative photographs of the *Echinopora lamellosa* fragments (a) after Phase 1 and the corals in the (b) control group (c,d) re-fragmented group after Phase 3. Scale bar = 2 cm.

Dead area

At the end of Phase 1, dead area was 18.7 ± 10.4 cm^2 for re-fragmented corals and 18.0 ± 14.1 cm^2 for control corals (Figure 1b) and the change in dead area was similar between the two treatments (Table 1). The initial dead area was a significant predictor of the change in live tissue area during Phase 1 (Linear regression, $F = 7.237$, $p = 0.01$, $R^2 = 0.136$; Figure 2b).

In Phase 2, the change in dead area was slightly higher for corals in the re-fragmented group compared to the controls ($p > 0.05$; Table 1). In Phase 3, dead area increased by 47.2 ± 34.5 cm^2 for corals in the re-fragmented group and 61.1 ± 31.9 cm^2 for control corals ($p > 0.05$; Table 1; Figure 1b; Figure 3). At the end of Phase 3, two re-fragmented corals from different colonies were dead. Overall, corals in the re-fragmented group had higher change in dead area (79.7 ± 35.4 cm^2) than the control corals (65.1 ± 46.8 cm^2; Figure 1b) but the difference was not significant ($p > 0.05$; Table 1).

Discussion

Optimising propagation and rearing processes in coral nurseries is essential for effective reef restoration. While substantial efforts have been devoted to enhancing the yield of sexually and asexually derived coral propagules (Forrester et al. 2013; Toh et al. 2012), few have explored the viability of re-fragmenting nursery-reared corals for re-stocking. Re-fragmentation could have the potential to support mariculture efforts and reduce collection from the wild (Forrester et al. 2013). In this study, we tested this approach by re-fragmenting nursery-grown *E. lamellosa* colonies. Our results demonstrated that despite generating more fragments, the increase in live-tissue area of the re-fragmented corals was about half that of the control fragments after one year.

The loss of coral tissue during the re-fragmentation process (Phase 2) was a drawback of this strategy. The re-fragmented *E. lamellosa* required approximately four to five months of growth to regenerate to their initial sizes, translating to a longer period needed for rearing this species in a nursery and a higher operational cost to maintain the nursery (Toh et al. 2017). This is unlike fragmenting other coral species such as *Acropora,* which can recover faster after fragmentation (Shaish et al. 2008; Raymundo & Maypa, 2004), and exhibit rapid and indeterminate growth (Highsmith, 1982). There was no evidence in this study to show that the initial live issue area affected growth, but smaller sizes can reduce coral survival (Highsmith, 1982). While this effect was not tested in the present study, we did observe that two re-fragmented corals died while those in the control were all alive after six months.

Additionally, the greater the extent of initial tissue mortality, the slower *E. lamellosa* fragments grew in the nursery. We observed that dead regions of the colony were rapidly colonized by fouling organisms (e.g. algae), corroborating the observations reported by Fishelson (1973). These organisms compete with the coral for space and further damage adjacent tissues (Fishelson, 1973; Toh et al. 2013). As more resources are needed to facilitate wound healing, coral growth can be delayed (Fong & Lirman, 1995; Lirman, 2000; Henry & Hart, 2005). Tissue necrosis also reduces coral immunity and increases their susceptibility to coral diseases (Sheridan et al. 2013). Consequently, tissue necrosis can spread rapidly (Titlyanov et al. 2005; Casey et al. 2015) and hinders the growth of coral fragments especially at the circumference (Osinga et al. 2011; Leal et al. 2014). This could account for why initial fragment live tissue area was a poor predictor of growth in this study. To mitigate the impact of tissue necrosis on growth, dead portions of cultivated corals should be removed to prevent spread of disease and reduce further mortality (Shafir et al. 2010; Sheridan et al. 2013).

Conclusion

Despite the reduced growth, the re-fragmentation method has the potential to produce more coral individuals. This can be useful in situations where healthy donor colonies are scarce, especially for endangered coral species (Lirman et al. 2010). Further research is needed to determine the time required for the secondary fragments of various coral species to recover and grow sufficiently before the next re-fragmentation (Soong & Chen, 2003; Forrester et al. 2013; Lohr et al. 2015). This will help optimize nursery coral production and reduce the overall dependence on natural donor colonies for propagation.

Acknowledgements

This study was carried out as part of the project "Enhancing Singapore's Coral Reef Ecosystem in a Green Port", funded by the Maritime and Port Authority of Singapore (Grant number R347-001-215-490).

References

Bowden-Kerby, A. (2001). Low-tech coral reef restoration methods modeled after natural fragmentation processes. *Bulletin of Marine Science, 69(2), 915-931*.

Bruckner, A. W. (2000). New threat to coral reefs: trade in coral organisms. *Issues in Science and Technology, 17(1), 63-68*.

Bruno, J. F., & Selig, E. R. (2007). Regional decline of coral cover in the Indo-Pacific: timing, extent, and sub regional comparisons. *PloS One, 2(8), e711*.

Casey, J. M., Connolly, S. R., & Ainsworth, T. D. (2015). Coral transplantation triggers shift in microbiome and promotion of coral disease associated potential pathogens. *Scientific Reports, 5, 1-11*.

Cumming, R. (2002). Tissue injury predicts colony decline in reef-building corals. *Marine Ecology Progress Series, 242, 131-141*.

Dai, C. F. (1993). Patterns of coral distribution and benthic space partitioning on the fringing reefs of southern Taiwan. *Marine Ecology, 14(3), 185-204.*

Dizon, R. T., & Yap, H. T. (2006). Effects of coral transplantation in sites of varying distances and environmental conditions. *Marine Biology, 148(5), 933-943*.

Edwards, A. J., & Clark, S. (1999). Coral transplantation: A useful management tool or misguided meddling? *Marine Pollution Bulletin, 37(8-12), 474-487.*

Edwards, A. J., & Gomez, E. D. (2007). *Reef restoration concepts and guidelines: making sensible management choices in the face of uncertainty*. Coral reef targeted research & capacity building for management programme. St Lucia, Australia.

Epstein, N. R., Bak, R. P. M., & Rinkevich, B. (2003). Applying forest restoration principles to coral reef rehabilitation. *Aquatic Conservation: Marine and Freshwater Ecosystems, 13(5), 387-395*.

Fishelson, L. (1973). Ecological and biological phenomena influencing coral-species composition on the reef tables at Eilat (Gulf of Aqaba, Red Sea). *Marine Biology, 19(3), 183-196*.

Fong, P., & Lirman, D. (1995). Hurricanes cause population expansion of the branching coral *Acropora palmata* (Scleractinia): wound healing and growth patterns of asexual recruits. *Marine Ecology, 16(4), 317-335*.

Forrester, G., Dauksis, R., & Ferguson, M. (2013). Should coral fragments collected for restoration be subdivided to create more, smaller pieces for transplanting? *Ecological Restoration 31(1), 4-7*.

Green, E., & Shirley, F. (1999). *The global trade in coral*. Cambridge, UK: World Conservation Press.

Highsmith, R. C. (1982). Reproduction by fragmentation in corals. *Marine Ecology Progress Series, 7(2), 207-226.*

Leal, M. C., Ferrier-Pagès, C., Petersen, D., & Osinga, R. (2014). Coral aquaculture: applying scientific knowledge to ex situ production. *Reviews in Aquaculture, 6, 1-18.*

Lirman, D. (2000). Fragmentation in the branching coral *Acropora palmata* (Lamarck): growth, survivorship, and reproduction of colonies and fragments. *Journal of Experimental Marine Biology and Ecology, 251(1), 41-57.*

Lirman, D., Thyberg, T., Herlan, J. Hill, C., Young-Lahiff, C., Schopmeyer, S., Huntington, B., Santos, R., & Drury, C. (2010). Propagation of the threatened staghorn coral *Acropora cervicornis*: methods to minimize the impacts of fragment collection and maximize production. *Coral Reefs 29(3), 729-735.*

Lohr, K. E., Bejarano, S., Lirman, D. Schopmeyer, S., & Manfrino, C. (2015). Optimizing the productivity of a coral nursery focused on staghorn coral *Acropora cervicornis*. *Endangered Species Research, 27(3), 243-250.*

Ng, C. S. L., Ng, S. Z., & Chou, L. M. (2012). Does an ex situ coral nursery facilitate reef restoration in Singapore's waters? In: K. S. Tan (Ed.), *Contributions to Marine Science* (pp. 95-100). Singapore: National University of Singapore.

Ng, C. S. L., Lim, S. C., Ong, J. Y., Teo, L. M. S., Chou, L. M., Chua, K. E., & Tan, K. S. (2015). Enhancing the biodiversity of coastal defence structures: transplantation of nursery-reared reef biota onto intertidal seawalls. *Ecological Engineering, 82, 480-486.*

Ng, C. S. L., Toh, T. C., & Chou, L. M. (2016). Coral restoration in Singapore's sediment-challenged sea. *Regional Studies in Marine Science, 8, 422-429.*

Osinga, R., Schutter, M., Griffioen, B., Wijffels, R. H., Verreth, J. A. J., Shafir, S., Henard, S., Taruffi, M., Gili, C., & Lavorano, S. (2011). The biology and economics of coral growth. *Marine Biotechnology, 13(4), 658-671.*

Pomeroy, R. S., Parks, J. E., & Balboa, C. M. (2006). Farming the reef: is aquaculture a solution for reducing fishing pressure on coral reefs? *Marine Policy, 30(2), 111-130.*

Raymundo, L. J., & Maypa, A. P. (2004). Getting bigger faster: mediation of size-specific mortality via fusion in juvenile coral transplants. *Ecological Applications, 14(1), 281-295.*

Rinkevich, B. (2005). Conservation of coral reefs through active restoration measures: recent approaches and last decade progress. *Environmental Science and Technology, 39(12), 4333-4342.*

Schneider, C. A., Rasband, W. S., & Eliceiri, K. W. (2012). NIH Image to ImageJ: 25 years of image analysis. *Nature Methods, 9(7), 671-675.*

Shafir, S., Edwards, A., Rinkevich, B., Bongiorni, L., Levy, G., & Shaish, L. (2010). Constructing and managing nurseries for asexual rearing of corals. In: Edwards. A. J. (Ed.), *Reef rehabilitation manual* (pp. 49-72). St Lucia: Coral Reef Targeted Research & Capacity Building for Management Program.

Shaish, L., Levy, G., Gomez, E., & Rinkevich, B. (2008). Fixed and suspended coral nurseries in the Philippines: Establishing the first step in the "gardening concept" of reef restoration. *Journal of Experimental Marine Biology and Ecology, 358(1), 86-97.*

Sheppard, C. R. C. (1980). Coral cover, zonation and diversity on reef slopes of Chagos atolls, and population structures of the major species. *Marine Ecology Progress Series, 2(3), 193-205.*

Sheridan, C., Kramarsky-Winter, E., Sweet, M., Kushmaro, A., & Leal, M. C. (2013). Diseases in coral aquaculture: causes, implications and preventions. *Aquaculture, 396, 124-135.*

Smith, L., & Hughes, T. (1999). An experimental assessment of survival, re-attachment and fecundity of coral fragments. *Journal of Experimental Marine Biology and Ecology, 235(1), 147-164.*

Soong, K., & Chen, T. A. (2003). Coral transplantation: regeneration and growth of *Acropora* fragments in a nursery. *Restoration Ecology, 11(1), 62-71.*

Titlyanov, E. A., Titlyanova, T. V., Yakovleva, I., Nakano, Y., & Bhagooli, R. (2005). Regeneration of artificial injuries on scleractinian corals and coral/algal competition for newly formed substrate. *Journal of Experimental Marine Biology and Ecology, 323(1), 27-42.*

Toh, T. C., Guest, J., & Chou, L. M. (2012). Coral larval rearing in Singapore: observations on spawning timing, larval development and settlement of two common scleractinian coral species. In: K. S. Tan (Ed.), *Contributions to Marine Science* (pp. 81-87). Singapore: National University of Singapore.

Toh, T. C., Ng, C. S. L., Guest, J., & Chou, L. M. (2013). Grazers improve health of coral juveniles in ex situ mariculture. *Aquaculture, 414, 288-293.*

Toh, T. C., Ng, C. S. L., Peh, J. W. K., Toh, K. B., & Chou, L. M. (2014). Augmenting the post-transplantation growth and survivorship of juvenile scleractinian corals via nutritional enhancement. *PloS one, 9(6), e98529.*

Toh, T. C., Ng, C. S. L., Loke, H. X., Taira, D., Toh, K. B., Afiq-Rosli, L., Du, R. C. P., Cabaitan, P., Sam, S. Q., Kikuzawa, Y. P., Chou, L. M., & Song, T. (2017). A cost-effective approach to enhance scleractinian diversity on artificial shorelines. *Ecological Engineering, 99, 349-357.*

Veron, J. (2000). *Corals of the World, vol. 1-3*. Townsville: Australian Institute of Marine Science.

Contact email: lokemingchou@gmail.com

Research on Small Power Conditioners for Photovoltaic Power Generation Installed on Public Facilities

Keiju Matsui[1,2], Chubu University, Japan
Eiji Oishi[1], Chubu University, Japan
Mikio Yasubayashi[2], Chubu University, Japan
Yuuichi Hirate[2], Chubu University, Japan
Sudip Adhikari[2], Chubu University, Japan
Masaru Hasegawa[2], Chubu University, Japan

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
Photovoltaic–PV power generations has been spread around the world. In such system, power conditioners that is used for conversion from dc to ac and is much important, so it has been studied by many researchers. In addition to usual utilization, such PV generation is often supplied for the time of disaster. Usually such solar panels having limited power are almost installed on top of the roof of the building and the like. In such applications, some medical institutions or some public facilities have fairly desire to keep such kind of power. For almost electrical equipment using in such medical facilities, even instantaneous interruption could never be permitted. The generating power in a case is quite limited, so the system construction should balance the reduced power. Thus, it is necessary to improve the construction toward simple one. In this research, in a process to study such system, the simple and concise power converters have been found by the authors. Considering rather narrow space of installation, the system constructions should be compact. The circuit which gratifies their operating characteristic is presented. In a series of the study, this time, dc to ac converter is analytically discussed about circuit construction as a novel circuit converter. This power conditioner is analytically discussed and the superior characteristic is presented. Unsatisfactory characteristic is improved by using some novel techniques.

Keywords: Veranda solar, PV power generation, Power conditioners, PVS, Solar panel, Photovoltaic power generation, Power converter, Inverter, Small power generation

iafor
The International Academic Forum
www.iafor.org

Introduction

Utility-interactive photovoltaic power generations have been realized and accepted widely. Various researches about power conditioners that interface between photovoltaic arrays and ac utility system have been also utilized. Such innovative conditioning systems have been also discussed. On the other hand, in the latest medical equipment, the development of the structural function in the operating system is remarkable. The endoscopic surgery including surgical robot and the catheter intervention have been applied, so such remarkable operating techniques have been developed with like robotic operating room and hybrid operating room[1,2]. For almost electrical equipment using in such medical facilities, even instantaneous interruption could never be permitted. In general, large scale interruptible power supplies installed by generators and batteries are provided. In such system, however, the system scale becomes so large which is accompanied by high cost. The power conditioners-PCS including inverter have been considered in various systems so far [3-5].

In the actual application, such solar panel is installed on top of the roof of the building or limited space. Some users of public or medical facilities are having a fairly strong desire to install such interruptible power supply using natural energy generation with low cost. In this study, in order to give the reply, a simple and concise photovoltaic power generation system is to be considered and discussed. Considering fair reduced generation power and limited space of installation, the system constructions should be simple and concise. In this research, the circuit which gratified their wishes are presented. System circuit and their sophisticated construction will be presented and analyzed. In such discussions, there are many subjects to be solved to utilize the PV power in utility interactive power generation. Even more, various safeguard equipment required according to regulations make the cost increase. Thus, it is required to obtain even more low cost PCS. In an extremely lower capacity PCS like proposed one, a way of handling would be different compared to conventional ones. In such case of reduced generating power, quantities of regenerating power to the power system would be small, where another mitigated regulation or deregulation would be approved. Thus, in such photovoltaic power generation systems, there are so many subjects to be resolved.

Half Bridge Circuit Configuration and its Outline

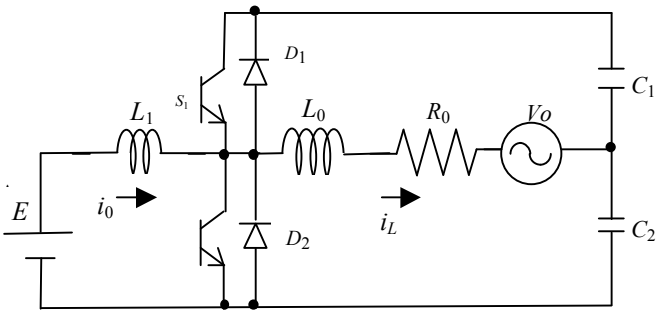


Fig.1. Proposed PCS constructed by half bridge.

Fig.1 shows an example of proposed PCS (Power Conditioners) which is constructed by the half bridge construction [6,7]. The single phase or three phase constructions using full-bridge circuit are possible for the PCS, but the operation is begun to discuss from fundamental half-bridge circuit. In the conventional inverter, the boosted output

voltage from boost converter is given to the dc link voltage terminal as usual connection. In the proposed PCS, however, the output voltage is given to the midpoint of inverter leg through accompanied inductor as shown.

For the switches S_1 and S_2 which are operating for normal load of L_o and R_o or ac power source V_o of utility interactive operation, the regular signals are given as usual, where L_o is line inductance R_o is line resistance. In this control strategy, for example, of natural sampling method (triangular-sinusoidal wave comparison method), as the average turned-on ratio is given by $\alpha = 0.5$, the dc link voltage of inverter is boosted by two times which can be calculated from the theory in boost converter. As a result, the input dc power supply voltage can be boosted by two times. In such a way, $2E$ voltage can be obtained across the inverter capacitors, where E is input dc supply voltage. S_2 plays also a role of the function of boost converter switches. By means of using merely single inverter construction, a novel inverter construction having boosted voltage capability can be obtained. The dc link voltage of inverter is given by

$$V_I = E/(1 - d) \quad (1)$$

where d : the average value of duty ratio

E : Input power supply voltage.

Assuming the sinusoidal and triangular wave comparison method, regardless of the modulation factor (ratio of sinusoidal amplitude / triangular amplitude), average value of conduction factor becomes $d = 0.5$. Consequently, inverter dc link voltage becomes $V_I = 2E$. The voltage V_L across L is given by subtracting input voltage from point A voltage, that is

$$V_A = V_L + E \quad (2)$$

In the load circuit, $V_A = V_o + E$ (3) ,

where V_o is load voltage including line inductance and resistance voltage.

Consequently, $V_L = V_o$ (4)

It can be seen that applied voltage across the input inductor becomes fairly large, so subsequent current becomes also large, whose value should be suppressed by input inductance itself. The applied voltage frequency is lower commercial one, so in order to suppress the input current, input inductance should be selected as a little increase. That characteristic is considered to be a weakness. In order to improve that characteristic, a novel control strategy is proposed.

Actual Application to Proposed Power Conditioner

(A) Buck converter compensation

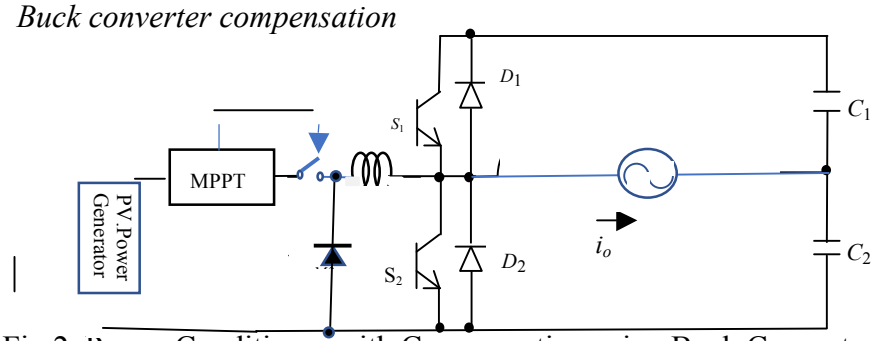


Fig.2. Power Conditioner with Compensation using Buck Converter.

Fig.2 shows the power conditioner for the purpose to improve the input current characteristic. By using of compensation due to buck converter, the deteriorated operation can be improved. In the actual application of usual PV generation, it is necessary to employ the MPPT(Maximum Power Point Tracker). In a case of Fig.2, by means of buck converter, maximum power point operation is executed and can be kept as constant power point operation at maximum power point. In this operation, switching current of buck converter is kept almost constant current during short period as just like the current source type operation. As a matter of course, according to changing of the amount of solar radiation, the controlled current of buck converter is also varied. In the short term, however, input current can be kept constant, so it can be called this converter operation as the current source converter.

In the output side inverter, the switching operation of S_1 and S_2 is executed by following equation.

$$V_o = aE \times \sin\omega t \qquad (5)$$

where a is modulation index.

According to the execution of natural sampling modulation, each pulse width is given by the value of this equation. Even if the modulation index a is varied, dc link voltage can be kept constant. The reason can be resolved as following discussion. In the half bridge inverter, when the modulation index is given by zero, the output waveform is given by pure rectangular waveform having equi-pulse width. The duty factor of switch S_2 is $d = 0.5$. As a result, the output dc link voltage is

$$V_o = 1/(1-d) = 2.0 \times E \qquad (6)$$

When the sinusoidal waveform is required to solve, the duty factor d is given by

$$d_{sin} = d + a\sin\omega t \qquad (7)$$

By means of this equation, output pulse width is obtained. The dc link voltage is resolved by means of this average value. That is,

$$D_{sin} = (1/2\pi)\int d_{sin}\, d\omega t$$

$$= (1/2\pi)\int(d + a\sin\omega t)\, d\omega t \qquad (8)$$

Consequently, because of

$$\int a\sin\omega t)\, d\omega t = 0 \qquad (9),$$

following result can be obtained as

$$D_{sin} = d. \qquad (10)$$

Consequently, dc link voltage becomes,

$$E_{dc} = E/(1-d) = 2E, \qquad (11)$$

in a case of d=1/2.

In a synchronous carrier of S_1 , S_2 and S_M, there are two types timing. For first case of (a), one is that S_M is turned-on when S_2 turned-on. The second case of (b) is that S_M is turned-on when S_2 turned-off.

- (a) For S_M-on and S_2-on, Power injection mode,
- (b) for S_M-on and S_2-off, Discharge boost mode,
- (c) for S_M-off and S_2-on, Power circulating mode,
- (d) for S_M-off and S_2-off, Regenerating mode.

In a case of (a), PV power is directly injected into input inductor L_1. This operation is the same one compared to the usual chopper power injection. In a case of (b), the stored charge during case (a) is discharged toward capacitor C_1 and C_2. Usually PV voltage is boosted by this operation. In a case of (c), because of S_M-off state, PV

power is not connected and not supplied, so the storage power is circulating through L_1, S_2 and D_3. In a case of (d), the storage energy of inductor is regenerated towards capacitor C_1 and C_2. By means of this operation, the current is toward reducing.

Usual weakness that had better improve is to suppress the input current variation, especially increase due to sinusoidal waveform. Such deterioration can be modified above mentioned circuit performance. Such operation can be adapted to improve. For a case of (a), S_M-on and S_2-on, power injection mode operation, the modulation signal is modified. The duty factor d is given by

$$d_{sin} = d + a\sin\omega t \qquad (12)$$

The second term $a\sin\omega t$ is varied from zero to a. Due to this over modulation and from boost voltage theory, the input current is fairly increase. Instead of this modulation, another modulation due to S_M operation is employed.

By means of this equation, output pulse width is obtained. The dc link voltage is resolved by means of this average value. That is,

$$Dsin = d + \left(\frac{1}{2\pi}\right)\left(\int_0^{\pi} a\sin\omega t\, d\omega t + \int_{\pi}^{2\pi} a\sin\omega t\, d\omega t\right) \qquad (13)$$

By assuming $a = 1$, $d = 0.5$ 、 and from 0 to π, the modulation index is adapted as d = 0.5, so in the right side, second term becomes,

$$\int_0^{\pi} a\sin\omega t d\omega t = 0 \qquad (14)$$

As a result,

$D_{sin} = 0.5 - (1/\pi) = 0.182$ (15)

From boosting voltage theory, that is

$E_{link} = 1.22$ (16)

If you want to increase the dc link voltage, instead of Eq.(A) where M is zero, following Equation where M is finite value from zero to unity.

$$\int_0^{\pi} M\, a\sin\omega t\, d\omega t \qquad (17)$$

(B) Boost converter compensation

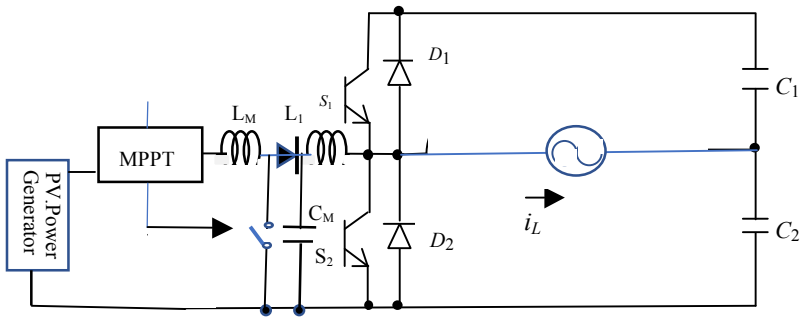


Fig.3. Power Conditioner with Compensation using Boost Converter.

Fig.3 shows the power conditioner for the purpose to improve the characteristic. It is different from just mentioned buck converter method, by using boost converter, the deteriorated operation can be improved. In the actual application of usual PV generation, it is necessary to employ the MPPT. In a case of Fig.3, by means of boost

converter, maximum power point operation is executed and can be kept as constant point operation at maximum power point In this operation, switching current of boost converter is kept almost constant current during short period as just like the current source type operation. As a matter of course, according to changing of the amount of solar radiation, the controlled current of buck converter is also varied. In the short term, however, input current can be kept constant, so it can be called this converter operation as the current source converter.

・(a) For S_M-off and S_2-on, Power injection mode.
When S_M is turned-off and S_2 is turned-on, power is injected into a series inductor of L_M and L_2.
・(b) for S_M-off and S_2-off, Discharge boost mode,
S_2 is turned-off and S_M is turned-off, power is delivered toward a series capacitor C_1 and C_2. The link voltage is going to increase.
・(c) for S_M-on and S_2-on, Power circulating mode,
When i_M is larger than i_{L1}, the input current is circulating, so that current is not increase.
・(d) for S_M-on and S_2-off, Regenerating mode.
S_M current increases and i_{L1} current is regenerating to dc link circuit of capacitor.

The function of capacitor C_M is as follows; If the current i_{LM} is larger than i_{L1} when the switch S_M is turned-off, in the usual operation, commutation from i_{LM} to i_{L1} cannot be performed satisfactorily. At that time excess energy is temporarily stored in the filter capacitor C_M. After that the commutation from i_{LM} to i_{L1} is completed.

Discussion will start from the initial modulation definition. Photovoltaic power is obtained by dc power from solar panel, so it is required to convert into the ac power for actual applications. At the first stage, that power is boosted to adequate voltage level, so the power is processed by boost converter. According that procedure, the power is converted to ac power. That control signal is obtained as PWM signal. The representative signal processing method is given

By natural sampling modulation. The sinusoidal waveform is given by

$$e_s = E_s \sin\omega t, \quad (18).$$

$$e_r = E_R \,\mathrm{tri}\omega t, \quad (19).$$

where formula symbol “tri” means triangular waveform shown in Fig.3. In Fig.3, PWM signal eo is given by following procedure.
When $e_s > e_r$, then

$$e_o = E \quad (20).$$

and when $e_s < e_r$, then

$$e_o = -E. \quad (21).$$

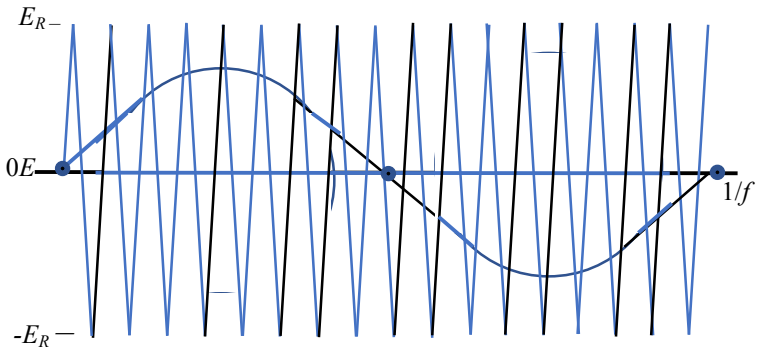
Assume that the switching frequency is much high, then the output waveform can be obtained as follows; In the figure, on the upper side relative to zero axis,

$$e_{up} = E/2 + aE/2 \sin\omega t \quad (22).$$

$$e_{down} = E/2 - aE/2 \sin\omega t \quad (23).$$

where a is modulation factor, that is

$$a = E_s/E_R. \quad (24)$$



Summation of these equations gives subsequent equation, that is,
$e_{up} - e_{down} = aE\sin\omega t$ (25).
When the load is operating in the sinusoidal waveform with commercial frequency, the fundamental performance is a little different compared to high frequency inverter to above mentioned. Consequently, the auxiliary inductor voltage is also different. The voltage of such inductor can be obtained as follows;
When S_2 is turned-on, applied voltage across the inductor is
$E_L = aE\sin\omega t$. (26).

When S_2 is turned-off, the voltage of
$e_L = E_C - aF\sin\omega t$ (27).
This voltage is applied across the auxiliary inductor. Actually, the value of voltage is varying across the half period, so it is necessary to calculate the average value. By means of this value, the necessary magnetic flux of inductor can be calculated. That is,
$E_{oave} = \int aE\sin\omega t \, dt/\pi = 2aE/\pi$ (28)
$= \int (E_C - aF\sin\omega t \, dt$ (29).

Assume that $E_C = F$, then
$a = \pi/4 = 0.785$ (30).
The modulation factor has an upper limit value as shown. Beyond of this value, the modulation factor could not be exceeded.

Conclusions

In a series of research as “Pursuit of ideal power conditioners”, an achievements can be attained on the process in the considering. For as one of those, the improved converter is proposed and analytically discussed for high performance whose idea is obtained from MPPT of the photovoltaic power generation system. In the first version which can realize by buck chopper, in which the boost chopper could be applied as suppression of input current. Some analytical characteristics can be realized. In the second version, by boost chopper of MPPT, input current chatacteristics could be improved. The original strategy of these converters has been proposed by the authors. The most important characteristic is compact and concise construction and is adequate one for small power converter.

The authors have been researching about superb photovoltaic power generation

system for medical facilities. In such place employing electrical equipment is strictly required in the standard based on regulation like “Japan Industry Standard” [13], where the standard of medical electrical equipment is determined. In the standard, that is in part 1: General requirements for basic safety and essential performance is dictated. The important degree of emergency power supply for medical electrical equipment is varied according to its treatment for medical electrical equipment like life sustainable system, operating room light maintenance [14]. For example, in artificial respiration equipment or patient monitor, if no battery installation system is adapted, such power supply system is not permitted. In optimum design specification of PV power generation system, adaptive installation may be required.

In the near future, with a spread of ultra-large-capacity and ultra-high-speed internet communication system, remote control surgery like in remote island may be possible, it is said. In such a case, even more reliable power supply system is important. In the important ME equipment,

In the proposed converter for load voltage, the supply voltage can be applied directly as advantage. The maximum, current of component is double of load current as disadvantage. For proposed converter, the number of component is reduced which brings efficiency improvement.。 In lower two stages, the load voltage is reduced to half of the supply voltage as disadvantage, but the load current does not flow over load current. Comparing both inverters, the number of component of Buck Inverter is reduced by unity., which can be developed to dc to dc converter, as the number of conversion stages is reduced satisfactorily, an improved efficiency can be achieved. Finally as looking at the whole view compared with the usual half bridge construction, one of double supply capacitors is replaced by dc power supply from regular position, that is an interesting appearance.

Acknowledgements

This research is mostly supported by a grant of Research Institute for Life and Health Sciences of Chubu University - Short Term Research Project). We would like to express our appreciation to who it may concern about this project.

The paper is proposed and presented whose idea is obtained from unified inverter circuit constructed by chopper and inverter circuit. In the first version which can realize sinusoidal wave, the number of the circuit construction can be made minimum. The number of the conventional corresponding circuit configuration is totally ten, while for the proposed construction, the number is eight. This result is the reason why the proposed inverter is called as minimum circuit construction.

In parallel load method, which can be developed to dc to dc converter, as the number of conversion stages is reduced satisfactorily, an improved efficiency can be achieved. Finally as looking at the whole view compared with the usual half bridge construction, one of double supply capacitors is replaced by dc power supply from regular position, that is an interesting appearance.

Through this research, an adequate and feasible circuit construction as simple and concise power conditioners have been presented and analytically discussed.
The feature of proposed PCS systems is to pursue a lower cost one including the

construction cost. According to reducing the capacity, the cost of solar panel is reducing in proportion. The cost of PCS, however, is not reduced in proportion to capacity. A novel PCS suitable for small capacity is proposed. This system can be performed at minimum wiring work at construction.

By means of Feed-in Tariff, the PV power generation has been developed widely. It is very important that the end user feels an economic merit which brings wide spread of PV power generation like as social phenomenon. The most important thing is that the cost is lower than charge of electric company.

In additional important thing, the visualization tool could be mentioned, in which the generating power can be easily viewed like handy smart phone. By means of this tool, if the power can be measured as a “negawatt”, economical merit can be realized and confirmed by viewing. If our visualization tool is realized with “Trade of Negawatt”, which is promoted by Ministry of Economy, Trade and Industry. The veranda solar could be widely spread.

References

[1] http://www.asterdenki.co.jp/:"ASTER Electric Co. Ltd., Medical equipment manufacturing, 2018"

[2] http://hcea.umin.ac.jp/files/pdf/, : "Report of Uninterruptible Power Supply and Medical Engineering Equipment", Hokkaido Clinical Association Engineers, 2018

[3] Yan Hu, Keiju Matsui, Takashi Sugiyama, Kenji Ando and Isamu Yamamoto,"3kW Utility-interactive Power Conditioning System using Forward Converter", Proceedings of Static Power Converter Meeting in IEEJ, SPC-94-89,pp.49-56,(1994)

[4] Sakae Shibasaki, Isao Takahashi, Shinzo Sakuma, Noriyasu Mimura, Yoshihiko Asano, "Small Quantity and Thin Type 200W Inverter for Photovoltaic Systems", Proceedings of National Convention in IEEJ,739,pp.4-50-51, (1998)

[5] Satoshi Naruse, Keiju Matsui, Shiro Hirose: 'Utility-interactive power conditioner using forward converter with double switches', Proceedings of national convention in IEEJ, 839, 1999-3

[6] Keiju Matsui, Eiji Oishi, Mikio Yasubayashi, Masayoshi Umeno, Hideo Uchida,Masaru Hasegawa: "Proposal of Novel Inverter Constructed by Using Minimum Circuit Components IEEE-GCCE 2017, pp.623-627 2017.1

[7] Keiju Matsui, Eiji Oishi, Mikio Yasubayashi, Masayoshi Umeno, Yuuichi Hirate, Sudip Adhikari, Masaru Hasegawa: "Circuit Analyses and Discussions on Novel Inverters Having Minimum Circuit Components - Pursuit for photovoltaic simple power conditioner through circuit software - IEEE-ICESS-2018, pp.125-129, 2018-11

[4] R.L.Steigerwalt, A.Ferraro, and R.G.Turnbull: 'Application of power transistors to residential and intermediate rating photovoltaic power conditioners', IEEE Trans. Ind Appl,, 1983, IA-19, (2) pp. 254-260

[5] A.Khoder, K.Al-Haddad and V.Rajagopalan: ' Innovative utility-interactive dc to ac power conditioning system'. Conference Record of 1985 IEEE IAS Annual Meeting, Toronto, Canada, 1985, pp. 1151-1155

[6] Chihiro Okado. : 'Development of inverter for photovoltaic generation'. Proceedings of 10th Photovoltaic Generation System symposium, Tokyo, Japan, 1993, pp. 411 (in Japanese)

[7] R.L.Steigerwalt, B.K.Bose and P.M.Szczesny: Design and construction of an advanced power conditioning subsystem for small photovoltaic applications'. Sandia Report, SAND 83-7037, 1985

[8] Edit:Ohmsha,"Guide Book of Technical Standard Concerning Electrical Equipment",1st edit.,pp.52-63,pp.376-382, 2013

[9] Technical Committee for Customer Equipment, edit., "Indoor Wiring Regulation - electrical code for customer equipment", Electric Association of Japan,pp.858-860, 2012-3

[10] Keiju Matsui, Eiji Oishi, Y.Kawata, M.Yasubayashi, M.Umeno, H.Uchida,M.Hasegawa:" Simple and Concise Photovoltaic Power Generation Systems installed in Verandas of Apartment House", Journal of Japan IE,vo.94, no.6, 2015-6

[11] Mikio Yasubayashi, Keiju Matsui, Eiji Oishi, Masayoshi Umeno, Yasutaka Kawata, Hideo Uchida:"Novel Voltage Equalizers for Secondary Batteries including EDLCs using CW Circuit ", Proceedings on Industrial Application Engineering, pp.531-535(2015-3)

[12] Hlaing Kyi Pyar Khant, Keiju Matsui, Masaru Hasegawa, Mikio Yasubayashi, Masayoshi Umeno, Eiji Ooishi, "Discussion on Various Voltage Equalizers for EDLCs using CW circuit", IPEC2014, International Power Electronics Conference, pp.183-190 (2014-5)

[13] Keiju Matsui, Eiji Oishi, Yasutaka Kawata, Mikio Yasubayashi, Masayoshi Umeno, Hideo Uchida: "Pursuit of Simple Power Conditioner for Photovoltaic Small Power Generation", IEEE Industrial Electronics Conference, Yokohama, Proceedings of IEEE-IECON 2015, pp.556-561 (2015-11)

[14] **http://search.e-gov.go.jp/ : "**Japan Industry Standard : **JIS T 0601-1", 2017**

[15] http://hcea.umin.ac.jp/files/pdf/h24files/, " Emergency power supply and medical electrical equipment",2012.6

Contact email: keiju@isc.chubu.ac.jp

Scenarios and Impacts of Future Floods on Low Income Housing in Chiang Mai, Thailand

Nachawit Tikul*, Maejo University,Thailand
Sirichai Hongwitthayakon, Maejo University,Thailand
Punravee Kongboontaim, Maejo University,Thailand
Tanwutta Thaisuntad, Maejo University,Thailand
Punsak Pakdee, Maejo University,Thailand

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
This study aimed to estimate the risk of low-income people whose suffer livelihood problems and housing damage due to present and future flooding, which will be affected by climate change. Data about problems in livelihood and housing damage affected by various flooding characteristics of households were collected in three low-income settlements in Chiang Mai which experience different flood types: flash floods, drainage floods and river floods. The data about livelihood problems and housing damage was developed using mathematical models by using ordinal logistic regression methodology. The five variables included house style, flood depth, duration, flow velocity, and frequency. These variables were used in the models which estimated housing damage and living problems probability during the floods. Then the future flood scenarios of the household were put into the models. It was found that living problems and housing damage were different among the households even though they were in the same community. This difference was due to the variations in housing style and the flood characteristics of each household. These models could be used to estimate future living problems and housing damage of other low-income settlements. The results could be analyzed and used to design low-income housing that is more resilient to flooding.

Keywords: Damage, Flood, Flooding impact, Low income housing, Scenario.

iafor
The International Academic Forum
www.iafor.org

Introduction

Chiang Mai is an economic region and development center in northern Thailand. It is highly developed and possesses high tourism rates, a strong economy, rapid growth, and investment potential. At present, Chiang Mai's economy is ranked second in Thailand after Bangkok (Thai Chamber of Commerce, 2015). This city's growth has led to a rise in migration of people from surrounding areas to find jobs, which results in increasing numbers and expansion of existing low-income settlements around the city (Thawinpipatkul, 2005). There is interdependence between low-income settlements and cities. The cities promise more jobs and diverse income opportunities, and the low-income settlements are important to the urban economy, especially by providing unskilled labor in various industries (Katz, Kling, & Liebman, 2001; Edelman & Mitra, 2006). The Community Organization Development Institute's survey reveals that there are 132 slums with 25,459 households in Chiang Mai, which ranked third behind Bangkok and Nakhon Ratchasima. This number is predicted to increase in the future (Community Organizations Development Institute, 2011).

In normal situations, low-income people face many intractable housing problems such as overcrowding, poor housing, lack of land tenure, poor infrastructure and public utilities, and flooding due to the vulnerable location (Bagheri, 2012). It can be seen from 10 years ago that Chiang Mai sustained four extreme floods (Department of Disaster Prevention and Mitigation, 2013) that led to housing damage, living problems, and homelessness in various areas especially in low-income settlements (Bourque, Siegel, Kano, & Wood, 2006; Huchzermeyer, 2011). Therefore, they are predicted be prone to more frequent and severe flooding due to climate change impacts in the future (IPCC, 2013). This is consistent with studies of the projected future climate changes in Thailand (Shinawanno, 2010), which found that average annual rainfall is expected to increase in all regions. At the end of the century, it could rise by about 15-25% in terms of distribution areas and rainfall volume during the monsoon season. This means that there is an increased risk of flash floods, which can result in other flood disasters (Djalante & Thomalla, 2012).

This research aimed to predict the risks regarding low-income people's lives, damage to their property, and loss of habitat affected by future climate change in flooding scenarios. These risks were predicted under the terms of existing context and physical location. The results of the research can be used as a basis for preparation of measures to improve the low-income settlements and housing to foster resistance and resilience against future floods. Furthermore, this study's results can be used as basis data for low-income housing policy formulation. In addition, the models can be applied to estimate similar issues for other low-income settlements in the other areas.

Materials and Methods

Three low-income settlements i.e. Bansanku (21households), Samugkeepattana (64 households) and Kampangam (61 households) were selected for this study as shown in Figure 1. These communities have existed for over 10 years and have more than 20 households in each settlement. They are also located in different flood prone areas that have different flood characteristics, i.e. flash flood, drainage flood and river flood. Household geographic information, drainage, and housing style were collected by using a survey, and the data was put into a geographic information system (GIS).

Interviews and observations were included to collect flood information (flood frequency, duration of flood, flood depth and flood flow velocity) and flood impacts (livelihood problem and housing damage) from 2001 to 2015.

Figure 1 Location of the three low-income settlements

The housing damage and livelihood problem models were developed using ordinal logistic regression methodology, which is an extension of the general linear model to ordinal categorical data. Ordinal logistic regression was used to predict the ordinal dependent variable (housing damage) given one or more independent variables (flood characteristics and housing style). In addition, it enabled the researchers to determine which of all the independent variables had statistically significantly affected housing damage and livelihood problems (Pistrika & Jonkman, 2010; Wind, Nierop, Blois, & Kok, 1999). Therefore, these models were used to calculate the probability of housing damage and livelihood problems due to future flood characteristics.

Future flooding scenarios of the three low income settlements were created by using data from future climate projections for Thailand, which were based on dynamic downscaling of global climate change scenarios generated by the ECHAM4 GCM: A2 scenario (Shinawanno, 2010). It was the wettest scenario of all existing research in which the increase in the amount of rainfall and the results were close to the actual amount of rainfall in the study area. A grid area measuring 25x25 km covering the three areas of study (upper Ping River) was chosen, and the rainfall data from two periods 1980-2009 and 2020-2049 was used to calculate percentage change in various return periods of 2, 5, 10, and 25 years. The researchers predicted occurring rainfall in the future as shown in Table 1.

Table 1 One day duration probable maximum rainfall over the areas

Return Periods	ECHAM4 GCM: A2 scenario			Monitoring Stations in the Areas			
	1980-2009 (mm.)	2020-2049 (mm.)	Percentage Change	Samukeepattana and Kampangam		Bansanku	
				1980-2009 (mm.)	2020-2049 (mm.)	1980-2009 (mm.)	2020-2049 (mm.)
2-yrs	52	63	0.21	75.6	90.72	81.8	98.16
5-yrs	89	120	0.34	99.7	134.595	108.2	146.07
10-yrs	133	193	0.45	115.6	167.62	125.6	182.12
25-yrs	228	365	0.6	135.7	217.12	147.6	236.16

Future flooding characteristics in the areas were projected by using the synthetic unit hydrograph of Snyder (equation 1-3) and runoff coefficient (equation 4) of the Yom River in Phrae station (Y.20) that covered the study areas (Royal Irrigation Department, 2014). Runoff volumes (m3/sec) from 1 mm rainfall of each low-income settlement could be seen.

$$t_p = 0.75\, C_t\, (L * L_c)^{0.3} \quad (1)$$

$$q_p = 0.275\, C_p * A / t_p \quad (2)$$

$$t_r = t_p / 5.5 \quad (3)$$

$$CO(\%) = 3.4343 + 0.2343 * RF_{max} \quad (4)$$

where, L is length of the main channel from the outlet to the watershed divide in kilometer.

L_c is length of the main channel from the outlet to the center of gravity of the basin in kilometer.

A is drainage area in square kilometer.

t_p is the time-to-peak discharge in hour

C_p is storage coefficient from 0.56 to 0.69, using 0.60 for this study since they are the slope blends with the general plain.

C_t is coefficient for representation differences in types and locations of streams, generally ranging from 1.8 to 2.2, using 1.8 for this study since they were small areas.

q_p is unit-hydrograph peak discharge in cubic meter per second.

t_r is the time of recession in hour, which is triangular unit hydrograph.

RF is the greatest 1 day rainfall amount in millimeter.

The runoff volumes were calculated as the amount of water expected to flood in the areas according to drainage box culverts related to each low-income settlement location. Their cross-section and drainage capability (m^3/s) reduced to about 60%, which is closest to reality , were determined under the study assumptions, which were based on existing geography and public policy . The runoffs did not include the outside runoff and rainfall, which probably affected the study areas. The results showed the flood depth (meters) and flood duration (hours) to be used as variables to put into the models. By using this data, the probability of housing damage and livelihood problems at future flood characteristics of each household were calculated.

Results

1. Housing styles and geography

The three low-income settlements are located in different geographic areas. Bansanku is located 300.90 meters above the mean sea level (MSL) in a basin-like depression. Samunkeepattana is located in a drainage canal around 307.75 meters above MSL, but it is about 0.75 meters lower than the road and surrounding areas. Kumpangam is located along the Mae Kha canal with an average height of 304.47 meters above MSL. The area in each low-income settlement is at different heights; the contours are shown in Figure 2(A-C) with the dark color representing low-lying areas and the light color representing elevated areas.

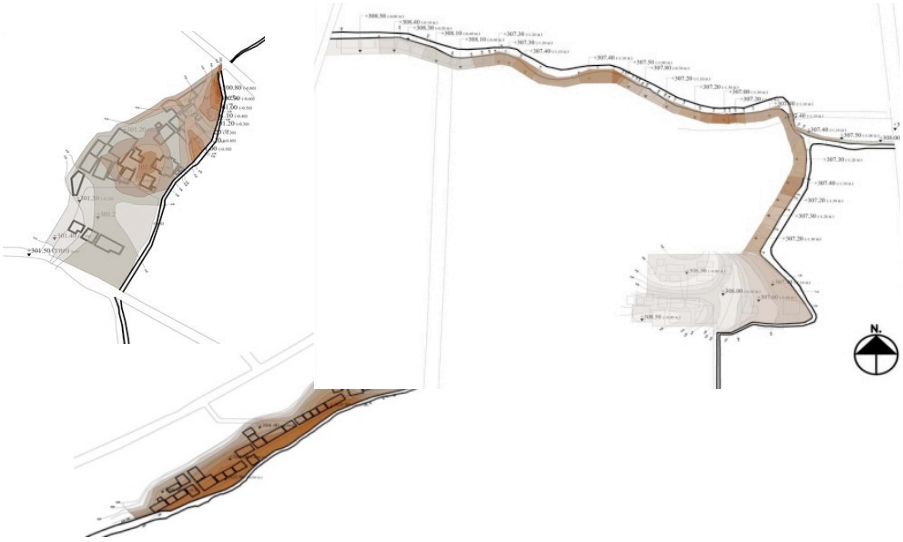


Figure 2 Geography and contour of the 3 low income settlements
(A) Bansanku's geography and contour
(B) Samunkeepattana's geography and contour
(C) Kampangam's geography and contour

The housing styles in the three slums were divided into eight styles (A-H) by house structure, construction materials, and number of floors. Styles A (1 floor), D (1 floor with high space under the house) and G (2 floors) are permanent houses, which refers to a house with strong structure, floors and walls built by reinforced concrete or wood in perfect condition and roofed by double corrugated roofing tiles or galvanized iron sheets as shown in Figure 3(A). Styles B (1 floor), E (1 floor with high space under the house) and H (2 floors) are semi-permanent houses, with structures and floors built from reinforced concrete or wood, walls made from light-weight material such as galvanized iron sheet and plywood, and roofed by double corrugated roofing tiles or galvanized iron sheets as shown in Figure 3(B). A small number of blocks and wood may be used. Styles C (1 floor) and F (1 floor with high space under the house) are non-permanent houses, which refers to a house with a wooden structure, floors and walls made by various materials such as galvanized iron sheets, wood, bamboo sheets or others, and roofed by double corrugated roofing tiles, galvanized iron sheets or other material as shown in Figure 3(C).

(A) (B) (C)

Figure 3 Examples of housing styles
(A) Permanent housing style
(B) Semi-permanent housing style
(C) Non-permanent housing style

From the survey, it was found that Bansanku and Kampangam had various housing styles in terms of functional area, structure and construction materials. Thirty percent of all houses in the two slums were in A style, followed by G and H styles. In Samunkeepattana, most of them were in E style, followed by A and D styles. D and F styles could not be found in Bansanku and D style could not be found in Kampangam as shown in Figure 4.

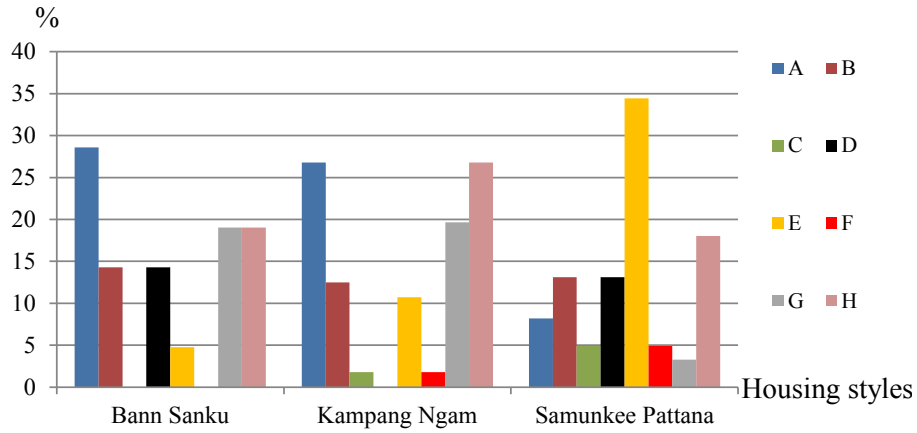


Figure 4 Housing styles in the three low-income settlements

2. Past and future scenarios of flood characteristics

The three communities have different flood characteristics such as flood frequency, duration of flood, flood depth, and flood flow velocity. It was found that Samunkeepattana experienced flash floods, which have high flood level, high flow velocity (>3 m/s), and frequent flooding (>15 time/yr) but short duration (<1 day). It was different from Bansanku, which experienced drainage floods—high flood level (0.7-1.1 m) but low flow velocity (slow-rising flood) and long duration (2-10 days). Kampangam sustained river floods from the Maekha canal; these floods have low flood level (0.5 m), middle flow velocity, frequent flooding and about 2 days flooding (as shown in Table 2). The future scenarios in return periods of 2, 5, 10, 25 years in term of flood duration and flood depth showed that the 2-year return period flood characteristics were not different from the actual floods in each community. If the return periods were 5, 10, 25 years, the flood would still have the same characteristics but with more extreme floods. For velocity flow and flood frequency, the data were taken from the actual information of each community.

Table 2 Past and future scenarios of flood characteristics of three low-income settlements

Community	Year	Flood Depth at Benmark (m)	Flood Duration (days)	Flow Velocity (m/s)	Flood Frequency (number/yr)
Bansanku	Regular flood	0.4	5	1.2	3
	2001	1.4	10	1.2	4
	2006	0.7	10	>1.2-1.5	3
	2011	0.9	6	>1.2-1.5	2
	2-yr return period	0.55	7	>1.2-1.5	4
	5-yr return period	1.24	7	>1.2-1.5	4
	10-yr return period	1.94	7	>1.2-1.5	4
	25-yr return period	3.26	10	>1.2-1.5	4
Kampangam	Regular flood	0.3	3	1.6	5
	2006	0.55	3	>1.6-2.0	4
	2011	0.7	4	1.6	4
	2-yr return period	0.67	2	>1.6-2.0	5
	5-yr return period	0.83	2	>1.6-2.0	5
	10-yr return period	1.11	4	>1.6-2.0	5
	25-yr return period	1.87	3	>1.6-2.0	5
Samunkeep.	Regular flood	0.5	3	3.4	15
	2001	0.65	1	>3.4	10
	2007	1.15	1.5	>3.4	15
	2011	0.7	1	3.4	15
	2-yr return period	0.58	2	>3.4	15
	5-yr return period	0.86	2	>3.4	15
	10-yr return period	2.39	2	>3.4	15
	25-yr return period	6.12	3	>3.4	15

3. Three low-income settlements' risk of flooding

The risks of 146 households from the floods were different depending on housing style and housing location, which is related to flood characteristics in 2001-2015. Therefore, some households were affected and some households were not affected by the floods at the same time. The housing damage was categorized into four levels (0-3) as shown in Table 3. The housing which did not sustain any serious damage (only becoming dirty) was considered at the 0-level. The 1-level damage was architectural damage which involved building materials or architectural components such as moldy doors, windows and walls. The 2-level damage involved structural damage such as columns and beams and could be recovered or repaired. If the houses were destroyed by the floods, it would be considered 3-level damage.

Table 3 Case processing summary of housing damage and living problem

		N	Marginal Percentage
Housing damage level	0	376	72.3%
	1	86	16.5%
	2	43	8.3%
	3	15	2.9%
Living problem level	0	242	46.5%
	1	215	41.3%
	2	63	12.1%
Flow	1	84	16.2%
	2	192	36.9%
	3	244	46.9%
TYPE	A	133	25.6%
	B	72	13.8%
	C	35	6.7%
	D	20	3.8%
	E	69	13.3%
	F	15	2.9%
	G	80	15.4%
	H	96	18.5%
Valid		520	100.0%
Missing		0	
Total		520	

The data in Table 4 shows that flood duration was not significantly related to housing damage. However, this study still used flood duration as a variable in the equation since the literature review found that long flood duration would increase housing damage level . The models fitting information were shown that satisfied as the chi-square test value was 230.076, the degree of freedom equals 12, which had a significant level higher than 0.01, or 99% of the models (Table 5). They were appropriate to be used to predict damage to housing in the future.

Table 4 Housing damage parameter estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Damage = .00]	2.726	.548	24.727	1	.000	1.652	3.801
	[Damage = 1.00]	4.344	.583	55.582	1	.000	3.202	5.486
	[Damage = 2.00]	6.088	.641	90.135	1	.000	4.831	7.344
Location	Dept	3.048	.333	83.846	1	.000	2.396	3.700
	Duration	0.029	.116	1.227	1	.268	-.099	.357
	Fequency	0.058	.112	5.275	1	.022	-.477	-.038
	[Flow=1.00]	0.211	.843	.063	1	.802	-1.863	1.441
	[Flow=2.00]	0.853	.486	3.082	1	.079	-.099	1.806

[Flow=3.00]	0[a]	.	.	0	.	.	.
[TYPE=1]	-0.041	.344	.014	1	.906	-.715	.634
[TYPE=2]	-0.030	.374	.006	1	.936	-.762	.702
[TYPE=3]	1.809	.549	1.230	1	.267	-.467	1.684
[TYPE=4]	-0.750	.658	.823	1	.364	-1.886	.693
[TYPE=5]	-0.302	.406	.554	1	.457	-1.097	.493
[TYPE=6]	1.425	.616	6.955	1	.008	.417	2.832
[TYPE=7]	-0.060	.406	3.412	1	.065	-1.545	.046
[TYPE=8]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

Table 5 Model fitting information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	792.779			
Final	562.703	230.076	12	.000

Link function: Logit.

For example, the equations predicted that style A at level 1 flow velocity would probably cause damage levels 0, 1, 2 and 3, as in equations (5)-(8). In the case that style A encountered a different type of flood characteristics, the equations could be used to calculate the probability of housing damage by substituting the variables (X_{1-3}) into them. For other housing styles (B-H), equations could be established as detailed in Table 4. There were 32 equations for predicting housing damage probability.

$$PD_0T_A = 1/(1+EXP(-(2.726-3.048X_1-0.029X_2-0.058X_3-(-0.041)-(0.211)) \quad (5)$$

$$PD_1T_A = 1/(1+EXP(-(4.344-3.048X_1-0.029X_2-0.058X_3-(-0.041)-(0.211))-P_0T_A \quad (6)$$

$$PD_2T_A = 1/(1+EXP(-(6.088-3.048X_1-0.029X_2-0.058X_3-(-0.041)-(0.211))-P_0T_A-P_1T_A \quad (7)$$

$$PD_3T_A = 1- P_0T_A - P_1TA - P_2T_A \quad (8)$$

where, PD_0T_A is the probability of 0 level damage to style A
PD_1T_A is the probability of 1 level damage to style A
PD_2T_A is the probability of 2 level damage to style A
PD_3T_A is the probability of 3 level damage to style A
X_1 is flood depth (meters)
X_2 is duration (days)
X_3 is frequency (number/year)

The data in Table 6 shows that the flood frequency, flow and type of housing was related to living problem levels. The flood duration was only slightly related to them but this study still used it as a variable in the equation since the literature review

found that long flood duration also affected to the living during the flood . The living problem model fitting information was shown that satisfied as the chi-square test value was 396.608, the degree of freedom equals (1)-(2), which had a significant level higher than 0.01, or 99% of the models (Table 7), so they were appropriate to predict living problems in the future.

Table 6 Living problem parameter estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Living Problem = 0]	1.137	.430	6.984	1	.008	.294	1.981
	[Living Problem = 1]	5.033	.525	91.951	1	.000	4.004	6.062
Location	Depth	3.226	.325	98.538	1	.000	2.589	3.863
	Duration	.032	.082	.156	1	.693	-.128	.192
	Frequency	-.411	.078	27.583	1	.000	-.565	-.258
	[TYPE = 1]	1.552	.328	22.409	1	.000	.909	2.195
	[TYPE = 2]	1.850	.375	24.360	1	.000	1.115	2.584
	[TYPE = 3]	3.996	.560	50.909	1	.000	2.898	5.094
	[TYPE = 4]	-1.875	.687	7.438	1	.006	-3.222	-.527
	[TYPE = 5]	-.433	.408	1.124	1	.289	-1.233	.367
	[TYPE = 6]	.845	.680	1.542	1	.214	-.489	2.178
	[TYPE = 7]	-.122	.376	.106	1	.744	-.859	.614
	[TYPE = 8]	0[a]	.	.	0	.	.	.
	[Flow = 1]	.637	.549	1.347	1	.246	-.439	1.714
	[Flow = 2]	.669	.367	3.320	1	.068	-.051	1.388
	[Flow= 3]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

Table 7 Model fitting information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	933.960			
Final	537.353	396.608	12	.000

Link function: Logit.

The equations from the data in Table 6 could predict the future living problems probability of each housing style (A-H) at level 0, which would allow the owners to live in their houses during the flood, and at level 1, at which they would experience one or more problems such as toilet problems, cooking problems or utility problems. The level 2 was the most extreme living problems. The owners could not live in their houses during the floods. The equations predicted living problem levels 0-2 of housing style A as shown as equations (9)-(11). In the case that style A encountered different types of flood characteristics, the equations could be used to calculate the probability of living problems by substituting the variables (X_{1-3}) into them. For other

housing styles (B-H), equations could be established as detailed in Table 6. There were 24 total equations for predicting future living problems probability.

PL_0T_A = $1/(1+EXP(-(1.137-3.226X_1-0.032X_2-(-0.411X_3)-1.552-0.637))$ (9)

PL_1T_A = $1/(1+EXP(-(5.033-3.226X_1-0.032X_2-(-0.411X_3)-1.552-0.637))-P_0T_A$ (10)

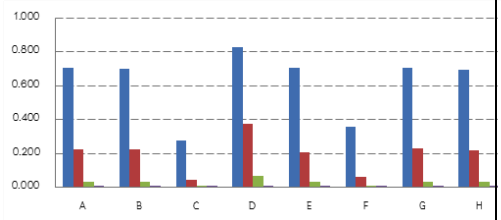
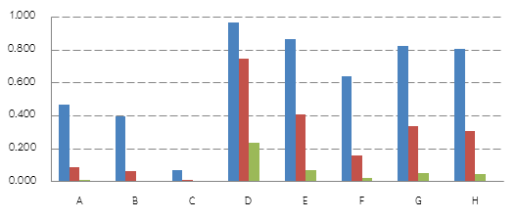
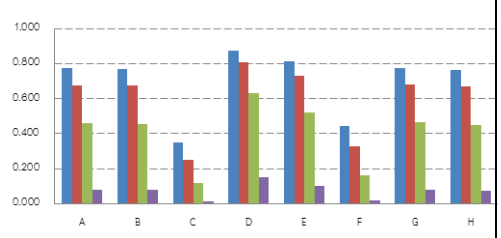
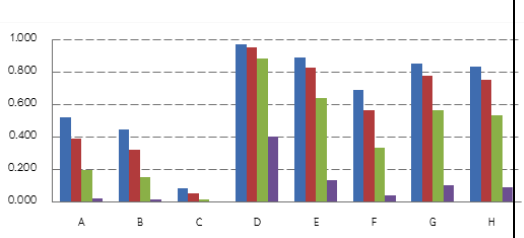
PL_2T_A = $1- P_0T_A - P_1T_A$ (11)

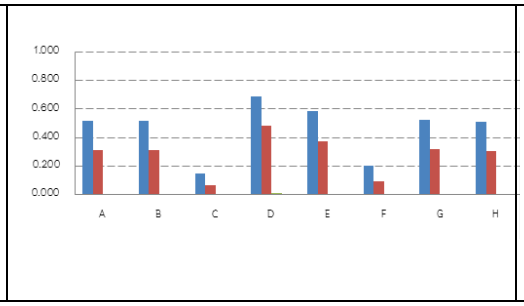
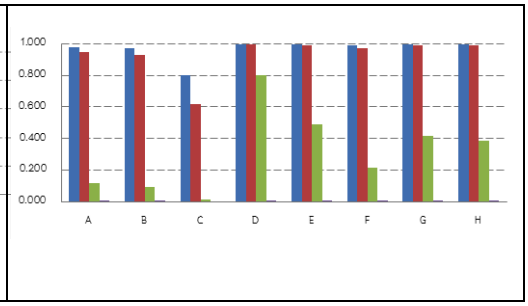
where, PL_0T_A is the probability of 0 level living problem to style A
PL_1T_A is the probability of 1 level living problem to style A
PL_2T_A is the probability of 2 level living problem to style A

The future risk of the household (probability of housing damage and living problem) of the three low-income settlements were predicted by housing style and future flood characteristics at return periods of 2, 5, 10 and 25 years. It was found that probability of non-problem in living (level 0) and non- damage of housing (level 0) would decrease parallel to the number of return period years. Kampangam had the least future risk of probability of both housing damage and living problems when compared to the others. Samukeepatana had more risk of living problems than housing damage and high probability to non-damage of housing in 2- and 5-year return periods. Bansanku had the highest risk during the 5-year return period.

In addition, it was found that C style was not suitable for the future flooding in these areas and the D, E, G and H styles should be chosen for every community. It is seen that high flood levels but short durations (<1 day) would affect living problems more than high flood levels and long durations. The number of floors of the housing was more important for living during the floods than structural and architectural parts, but all components of housing style were related to housing damage level.

Table 8 Future risk of the household of 3 low income settlements

Low Income Settlement	Probability of 0-Level in Living Problem	Probability of 0-Level in Housing Damage
Bansanku		
Kampangam		

Samunk.		

2 year return periods 5 year return periods 10 year return periods 25 year return periods

Discussion and Conclusion

The locations and existing geography of the low-income settlements affected the flooding and flood characteristics which are flood prone areas (Jabeen, Allen, & Johnson, 2010). The projected future flood scenarios of the study areas showed that all communities would experience high flood levels, and the 2- and 5-year return periods of flooding were likely the previous highest level but the 10- and 25-year return periods were very high. This flood changing affected the risk of housing damage and living problems. For example, the people in Bansanku did not suffered from previous floods, but in the future, the risk of flood damage will increase in parallel with the years of return periods. These results could be used for preparing future low-income housing in terms of the number of floors, structure and materials. Communities in the city with flash floods, similar to Samukeepattana's flood, should be concerned only about living problems since it was for a short duration although the people suffered the greatest impact from frequent, high-level, heavy flooding. The structural part of their houses was affected, so the house structures must be strong. Communities with drainage floods, similar Bansanku's flood, should be concerned about both living problems and housing damage. Bansanku frequently encountered high-level floods for a long duration, so the owners should prepare the housing with a high space underneath and permanent construction materials to ensure flood resiliency for about 15 days and at an average of more than 2 meters from the ground. In communities with river floods, similar to Kanpangam's flood, which was slightly damaged and sustained living problem by floods, all housing styles (A-H styles) could be built and only prepared for easy cleaning.

This research determined several limitations. The runoff was only from rainfall in the area—not accumulated water from other areas. In addition, existing geography and other conditions were determined, and the future policy related to drainage management was not included. Therefore, if the existing conditions were changed, the flood characteristics of the three communities would be changed and the risk would be changed, too (DTI, 2004; Land Development Department, 2014). In addition, it could be seen that the future flood scenarios and risk estimations were important before housing design. Some design issues were unnecessary for some communities, but they might be essential for others (Jabeen, Allen, & Johnson, Built-In Resilience: Learning from Grassroots Coping Strategies to Climate Variability, 2010). In addition, the flood details such as flood depth and duration were related to site selection, building structure, material selection, number of floors, building height, and building system. This resulted in cost savings and optimized architectural design for flood resilience in various areas.

Acknowledgements

Financial support from the Thailand Research Fund (TRF) for this research project is gratefully acknowledged.

References

Bagheri, M. (2012). The Challenge of Slums: Socio-Economic Disparities. International Journal of Social Science and Humanity, (5) 410-414.

Bourque, L., Siegel, J., Kano, M., & Wood, M. (2006). Handbook of Disaster Research. New York: Springer.

Chatterton, J., Viviattene, C., & Morris, J. (2010). The Costs of the Summer 2007 Floods in England. Bristol: Environment Agency.

Community Organizations Development Institute. (2011). Slums Report: Slums in Northern Areas. Chiang Mai: CODI Northern of Thailand.

Construction Research Division Research. (2011). Housing Standards and the Environment. Bangkok: National Housing Authority of Thailand.

Department of Disaster Prevention and Mitigation. (2013). Floods. Retrieved December 19, 2013, from http://61.19.54.141/yla/Acobat/flood.pdf

Djalante, R., & Thomalla, F. (2012). Disaster risk reduction and climate change adaptation in Indonesia: Institutional challenges and opportunities for integration. International Journal of Disaster Resilience in the Built Environment, (3) 166–80.

Douben, K. (2006). Irrigation and Drainage. Retrieved July 2014, 15, from Characteristics of River Floods and Flooding: A Global Overview: http://dx.doi.org/10.1002/ird.239

DTI. (2004). Foresight Future Flooding. London: Department of Trade and Industry.

Edelman, B., & Mitra, A. (2006). Slum dwellers' access to basic amenities: The role of political contact, its determinants and adverse effects. Review of Urban and Regional Studies, (18) 25-40.

Government Housing Bank: Academic section. (2013). Housing Market and Mortgage in 2012 and Trends in 2013. Retrieved December 8, 2014, from Government Housing Bank: http://www.ghbhomecenter.com/.../download.php?

Huchzermeyer, M. (. (2011). Cities with Slums: From Informal Settlement Eradication to A Right to the City in Africa. Cape Town: University of Cape Town Press.

IPCC. (2013). Fifth Assessment Report: Climate Change 2013: Synthesis Report. Retrieved March 6, 2017, from https://www.ipcc.ch/report/ar5/wg1/

Jabeen, H., Allen, A., & Johnson, C. (2010). Built-in resilience: learning from grassroots coping strategies to climate variability. Environ. Urban., (22) 415–431.

Jabeen, H., Allen, A., & Johnson, C. (2010). Built-In Resilience: Learning from Grassroots Coping Strategies to Climate Variability. Journal of Environment and Urbanization , 415-431.

Jonkman, S., Maaskant, B., Boyd, E., & Levitan, M. (2009). Loss of Life Caused by the Flooding of New Orleans After Hurricane Katrina: Analysis of the Relationship Between Flood Characteristics and Mortality. Risk Analysis, 676-698.

Katz, L., Kling, J., & Liebman, J. (2001). Moving to opportunity in Boston: Early results. Quarterly Journal of Economics, (116) 607-654.

Kreibich, H. (2009). Is Flow Velocity A Significant Parameter in Flood Damage Modelling? International Journal of Natural Hazards and Earth System Sciences, 1679-1692.

Land Development Department. (2014). Knowledge of Soil. Retrieved January 20, 2014, from http://oss101.ldd.go.th

Pardue, J., Moe, W., McInnis, D., Thibodeaux, L., & Valsaraj, K. (2005). Chemical and Microbiological Parameters in New Orleans floodwater Following Hurricane Katrina. Environ. Sci. Technol., 8591-8599.

Patanung, A. (2008). Impact of Flooding. Retrieved July 15, 2014, from https://www.gotoknow.org/posts/215379

Pecharanon, S. (2014). Urban Economics. Bangkok: Kasetsart University Press.

Pistrika, A., & Jonkman, S. (2010). Damage to Residential Buildings Due to Flooding of New Orleans After Hurricane Katrina. International Journal of Natural Hazards and Earth System Sciences, (54) 413–434.

Pistrika, A., & S.N., J. (2009). Damage to residential buildings due to flooding of New Orleans after hurricane Katrina. Natural Hazards, (54) 413-434.

Pornchokchai, S. (2014). The Wrong Development of Slums. Retrieved Jully 13, 2014, from http://www.skyscrapercity.com

Royal Irrigation Department. (2014). Information Systems for Monitoring and Surveillance for Flood Warning. Retrieved January 14, 2014, from http://imine.biz/imine_mixkey/index.php

Shinawanno, S. (2010). Projection of Future Climate Change, the Effects of Regional Climate Models –PRECIS. Bangkok: Center of Excellence for Climate Change Knowledge Management: CCKM.

Slomp, R., Kolen, B., Westera, H., Verweij, J., & Riedstra, D. (2016). Interpreting the impact of flood forecasts by combining policy analysis studies and flood defence. 3rd European Conference on Flood Risk Management. Lyon, France.

Sullivent, E., West, C., Noe, R., Thomas, K., Wallace, L., & Leeb, R. (2006). Nonfatal Injuries Following Hurricane Katrina—New Orleans, Louisiana, 2005. J Safety Res, 213–217.

Thai Chamber of Commerce. (2015). Potentiality and Economy of Chiang Mai. Retrieved January 13, 2015, from http://www.thaichamber.org

Thawinpipatkul, D. (2005). The Process of Urbanization and Social Change in Developing Countries. Bangkok: Chulalongkorn University Press.

United Nations Habitat. (2003). The Challenge of Slums: Global Report on Human Settlements. United Nations Human Settlements Programme. London: Earthscan Publications.

United Nations Habitat. (2009). Planning Sustainable Cities: Global Report on Human Settlements. United Nations Human Settlements Programme. London: Earthscan Publications.

Wind, H., Nierop, T., Blois, C., & Kok, J. (1999). Analysis of flood damages from the 1993 and 1995. Water Resources Research, (35) 3459-3466.

Contact email: nachawit@gmail.com

Far to go: Nine takeaways from a survey of businesses' progress on the journey to achieving the Sustainable Development Goals

Trista Bridges, Read the Air Coalition, Japan
Donald Eubank, Read the Air Coalition, Japan

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
This paper investigates the current status of companies that are updating their existing sustainability initiatives in light of the launch of the United Nation's Sustainable Development Goals (SDGs). Interviews were performed with more than 60 multinational corporations, SMEs, startups, investors and financial institutions, NGOs, industry associations and sustainability service providers. While the field of reporting on SDG impacts is in flux, most companies that have sustainability programs are aware of the UN's 2030 Sustainable Agenda and are trying to figure out how they can use their current approaches to sustainability to map their efforts to the SDGs. Companies that have set out on a sustainability journey have a wealth of options to choose from for measurement, disclosure and crafting strategy. But there is still far to go. Based on our research of how businesses are responding to the SDGs, we outline nine takeaways that capture the current state of progress of companies adopting sustainable business models. Our focus in this paper is on four that we believe are the most telling in terms of what it will take to make sustainability fundamental to business models: This is a journey that companies are on and no one has mastered it yet; companies must move beyond a "Vision" for Sustainability to fully systemizing their initiatives; employees want to understand how sustainability will impact their work; and there is a race for talent who understand sustainability.

Keywords: Sustainability, Business, Business Transformation, Change Management, Sustainable Development Goals, Disclosure

iafor
The International Academic Forum
www.iafor.org

Introduction

Over the past nine months, we have interviewed some 60 organizations worldwide—global corporations, mission-driven companies, investors, thought leaders, think tanks and industry associations—about their approach to using the United Nations' Sustainable Development Goals (SDGs) in a business context. We approached the subject with the thesis that more companies were using the SDGs to realign their business strategy and change their operations to improve their competitive posture and help meet the goals for society and the environment. In the process we became familiar with a wide range of philosophies of, systems for and challenges in operationalizing the SDGs for business. In this paper we cover our discoveries from our conversations with leaders of the corporate sustainability movement.

Our interviews took a qualitative approach, gathering stories from sustainability practioners, learning about best practices, understanding the investor perspective, and discovering the latest methodologies. At the same time, we have done background quantitative research on the number of companies hitting certain milestones in their sustainability journey; how companies embracing SDG programs are performing verse peers; and how the SDGs are being mapped across to business KPIs.

Now there's a plan

Suddenly the earth has a strategy. The release of the United Nations' Sustainable Development Goals in 2015 was the culmination of more than a century-long, international evolution in our understanding of social and environmental issues. As a result, the business world now has a new pilot in its social journey. The global consensus represented by the launch of the SDGs is intimately connected to the development of corporate philosophy and practices, in particular to an understanding of the responsibilities of business that goes back to the mid-20th century.

The launch of the SDGs has transformed Corporate Social Responsibility (CSR), Environment, Society, Governance (ESG) concepts and the other threads of corporate sustainability thinking into a whole new integrated approach to business. Now, with the best researched methodologies and new innovative tools, companies can make business cases for sustainability reporting and strategy development. They can adopting whole systems approaches to understand how their companies exist within their marketplaces, value chains and communities. And there are a wide range of options that they can choose from to do the most relevant reporting and operations transformations today.

At this point in the evolution of the sustainability field, when it comes to sustainability reporting, we believe that what is most striking today is what happens *after* reporting. Basic sustainability reporting activities have been well established for a while and are quickly becoming a de facto part of businesses' annual schedule, whether as CSR reports, standalone sustainability reports, or integrated reports that combine financial and sustainability accounting. Now, though, there is also a wealth of options that companies can apply when they look to take the next step and actually transform their business planning and strategy in order to more completely put sustainability in a core position. The key, though, is to spread these activities and knowledge beyond the sustainability practitioners in an organization to the broader work force that performs both the company's core and support functions.

Nine takeaways

While there is a sea change going on in the business world when it comes to its stance on sustainability, we quickly discovered in our research a host of common issues that businesses are struggling with across industries. The nine biggest takeaways we found are that:

1) Sustainability is not yet fundamental to business models—This is a journey that companies are on and no one has mastered it yet
2) Companies are trying to move beyond a "Vision" for Sustainability to fully systemizing their initiatives
3) Within organizations employees desire to understand sustainability and how it will impact their work
4) There is a race for talent, who are becoming pickier about a company's position on sustainability
5) Companies are struggling to measure and assess performance on the SDGs—there are a lack of widely agreed to frameworks and tools, which deters companies from fully moving their businesses toward sustainability
6) Investors are acting as enlightened managers of capital to light the way and drive adoption
7) Greenwashing is not possible, cheap talk is easy to uncover with new frameworks and benchmarking
8) The supply chain is a major focus of sustainability efforts; there is great room for progress here
9) Collaboration and partnership are essential to success; efforts required are too complicated to do alone

The first through fifth takeaways are highly indicative of the current status of progress of companies adopting sustainable business models. Needless to say, most companies have a long way yet to go in incorporating sustainability in their business models. It's a spectrum—a journey—and companies are at different points along the way.

Many companies have discussed the SDGs internally and, either on their own or with expert help, mapped their current business activities across to the 169 targets contained in the SDGs. Based on these activities, they have then determined which SDGs are the most important to their business and formulated a vision of where they want to be on a selection or all of the 2030 goals. But the next step of building a strategy around that vision and communicating it in a meaningful way throughout the organization, one that is understood, embraced and acted upon by their workforce, is a stumbling block for all but the best positioned of organizations—and a challenge to even the most advanced.

Talent both hold the key to making progress and are a risk to companies that are underperforming on sustainability. Employees that understand the concepts around sustainability and believe in a company's sincerity in addressing these is issues are vital to success.

Far to go

The organizations we spoke to largely said that their companies are broadly embracing the SDGs and, more generally, sustainability. Rather than reveal great progress in achieving sustainable business models, though, we were under the impression from these discussions tend to happen at an earlier stage of an organization's journey.

To confirm this, we looked at annual reports, which we saw as the most important document for communicating an organization's mission and strategy, of a range of businesses that were considered sustainability leaders. We found that the vast majority of companies surveyed are now mentioning the SDGs in their annual reports, have mapped the SDGs to their business activities and are discussing them in relation to their strategy (Figure 1).

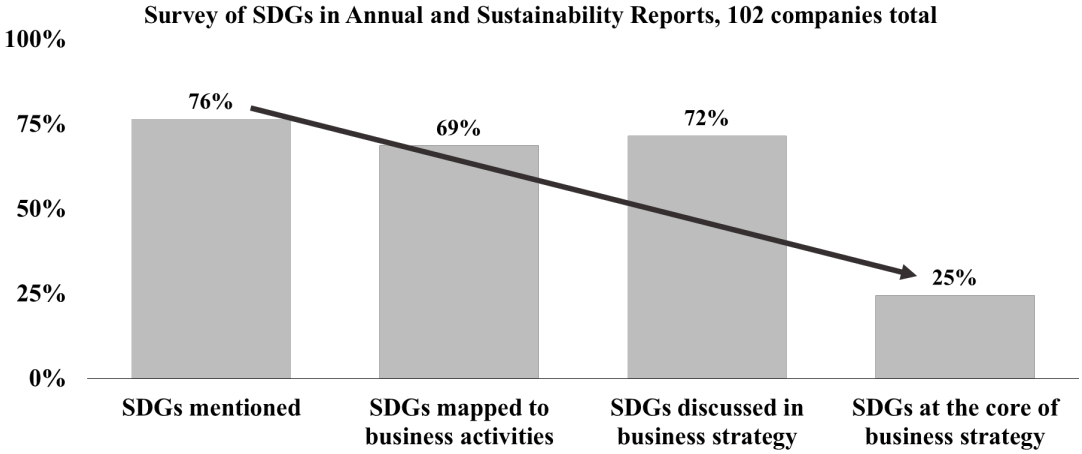


Figure 1 Organizational Factors

However, very few businesses have put the SDGs at the core of their business strategy. To assess this, we looked at what whether they are developing or already offer products and services that are "sustainable," if they're moving to operationalize sustainability in their strategy and operations via supply chain modifications, supplier validation and other initiatives, or if they see sustainability as a driver of growth and cost efficiencies going forward.

Our direct conversations with companies supported these findings. While we spoke with many leaders in the field of sustainability and discussed their ambitious visions and plans, it was apparent that almost none of them could be considered to have a fully sustainable business model. Thus it was apparent that sustainability is not yet fundamental to business models; this is a journey that companies are on and no one has mastered it yet. At the best, the majority of companies are at the stage of priority and vision setting for sustainability strategies, and struggling to move to the next level.

Taking the next step—From Vision to Execution

Aligning an organization around an ambitious Vision is challenging when dealing with traditional employee thinking on the role of company in society and their own responsibilities within and to an organization. Try to do this in a multinational that

encompasses varying cultures, experiences, market dynamics and perspectives and the efforts required are exponentially compounded. As with other aspects of business such as brand portfolio strategy, finance or operations, sustainability-driven strategies need to be understood and accepted as relevant to all business functions across the organization. (In the international case, they must also be adapted to local environments and situations in order to work.)

We realized in our research that there is still much work to do in improving communications, particularly internally. You cannot depend alone on the SDGs and your corporate Vision for them to successfully build knowledge about topics within your organization. And, while the CEO's voice is a critical in building alignment around transitioning the organization to sustainability, there must be even more communication tools in place besides just having the top executives express the importance of sustainability strategies. In fact, based on our understanding of how sustainability leaders have become trailblazers in their industries, they require a dedicated primary sustainability champion—typically the Chief Sustainability Officer or Vice President of Sustainability—plus an enlightened, engaged CEO, a forward-looking and compelling business case for the transformation, and a receptive work force in which more champions appear, all put together with a bit of good luck in timing of bringing all these elements together simultaneously.

Struggling to measure and assess performance

While we won't explore takeaway number 6 in depth here—that companies are struggling to measure and assess performance on the SDGs—it is worth quickly highlighting the importance of this observation. Once organizations decide to make an organizational transformation toward a sustainability/SDG-based model, they need to determine the concepts, tools, and frameworks to enable them to make the important decisions and define the key actions they'll need to take to adopt a sustainability/SDG-based business model.

The question around which methods to use can be a daunting one. A wide range of methods exist around the world, which makes the decision even more complex. All organizations will test various methods, and ultimately settle on the one or ones that best suits each organization's unique culture, mission, capabilities, product portfolio and people.

We've identified what we refer to as a Sustainability Operationalization Process (Figure 2) that specifies the key stages that an organization generally proceeds through when transitioning to this transformative business model. This outline of the process helps to identify at which stage an organization actually is.

Figure 2 The Sustainability Operationalization Process

Looking at the various concepts, tools, and frameworks through this process helps to

make it clear where they are most useful to organizations. The concepts, tools, and frameworks that we found to be the most widely used among the organizations we interviewed or studied over the course of our research, at different stages within the process flow were: SASB (in Stages 1 and 6), B Corp (Stage 3), Circular Economy (Stage 3 & 4) and Future-Fit (Stage 6). (We have discussed this subject at length in another paper, "Everything or Anything—How Businesses Can Start with the SDGs"[1].)

The Road to Understanding Sustainability

The journey to becoming a sustainability-centered organization was never be the same for any two organizations. While most drew on best practices from market leaders of various industries, they also were aware that their own journey was distinct, influenced heavily by its company culture, people, context, financial situation, geography, goals and history. One thing that all organizations needed do, though, is understand where they were along this path. We identified four principal phases that organizations tend to proceed through:

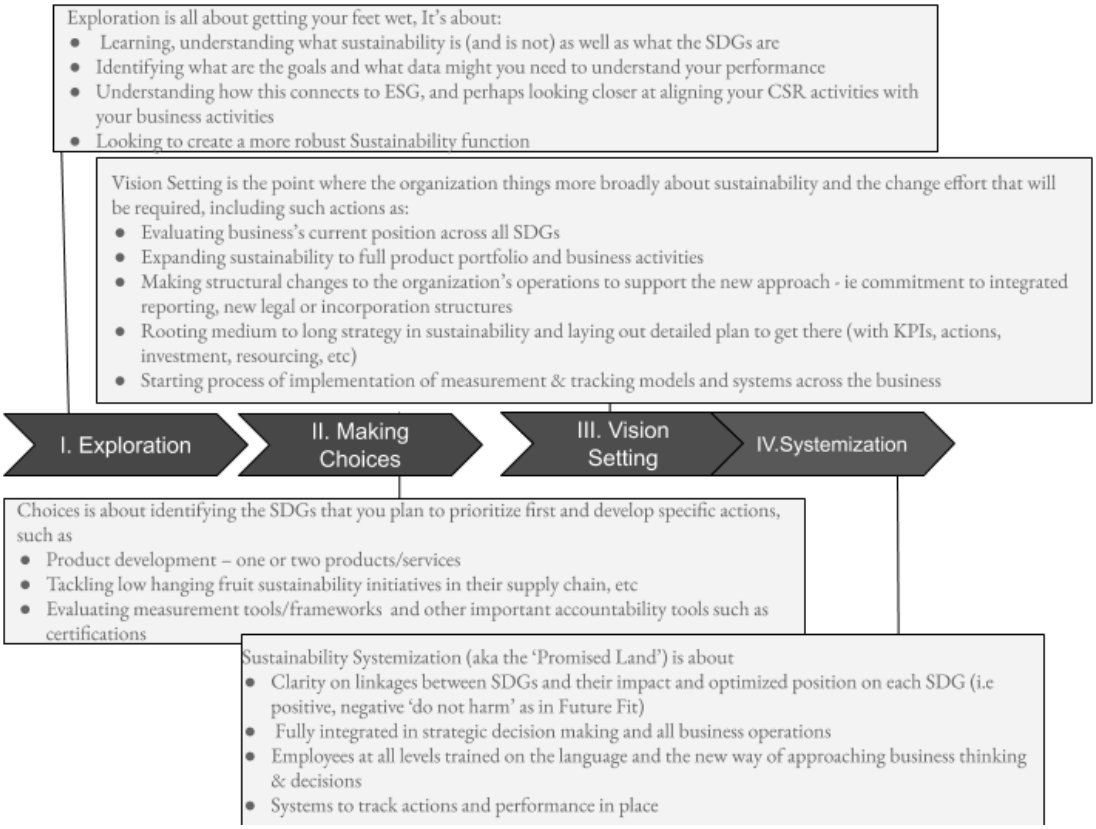


Figure 3 The Sustainability Operationalization Process

While Stages I and II, Exploration and Making Choices may seem like the 'lightweight' ones, each were critical and required a serious amount of dedication and work, as noted in Figure 3. Outside of "mission-driven organizations" that were built from the ground up around sustainable concepts, most of the companies we spoke with in our research were in stage II as we define it here.

[1] Bridges, T. & Eubank, D. (2019). Everything or Anything—How Businesses Can Start with the SDGs. *Journal of Business Administration (JBA, ISSN:1025-9627) volume 4, issue 1, 75-103*

While many have aligned their current actions with the SDGs or other sustainability frameworks and have set substantive business priorities in regards to sustainability, they also worked hard to get meaningful buy-in from senior leadership and other key stakeholders around an even more sustainability-oriented business approach. Successfully getting to stage II required significant effort and dedication, particularly from those in sustainability roles. However, this effort typically pales in comparison versus that for the company-wide change effort that is required in Stages III and IV, i.e. Vision Setting and Systemization.

The first, most critical question they needed to address is, "How do we manage the gargantuan task of building an organization that is capable—at all levels—of building and successfully managing a fully sustainable business?"

The concept of sustainability itself is one that can be vague and is, perhaps, becoming even more so over time. Though the term "sustainability" might hardly have been used in the early days of modern corporations, the concept in general, which was rooted in the notion of "doing good" in some capacity, has evolved greatly overtime. What started out as corporate philanthropy evolved into CSR, then ESG, and now, arguably, the SDGs. So it's somewhat of a moving target, always evolving and broadening in scope.

Those working day in and day out in roles that are directly connected to sustainability, often in departments and roles that are fairly separate and distinct from other functions within the organization, are on a continuous learning curve themselves. There may be many elements that they just "get" intrinsically, but there are many others that they're learning regularly. Thus with the business discipline of sustainability ever-evolving, building out a breadth and depth of sustainability capability is a significant challenge within both large and small organizations.

Still, though difficult, it's imperative for a company to figure this out if it wants to transform toward a sustainability-rooted business model. Before examining how to execute on the vision, they must understand what they need to do to build an organization that's capable of doing so in the first place.

From Vision to Systemization

While many organizations have various CSR and sustainability activities which are often led by the best and brightest in the sustainability field, these activities have been sitting for of them in the "important but non-business-critical" category. This positioning is beginning to shift, largely due to a significant change in mindset of those at the senior most levels in organizations.

Champions of sustainable business models within the organization, such as CSR managers and Heads of Sustainability, have long been advocating for a fundamental transformation in how business operates. With the significant challenges and risks facing society and, hence, all businesses today, the C-suite's mindset is now beginning to align with that of the sustainability champions.

Some CEOs have even taken bold moves to not only push for their organizations to align its business activities with the SDGs, but also view sustainability and the SDGs

as non-negotiable realities for businesses. A powerful example is Yoshinori Yamashita, CEO of the imaging and electronics company Ricoh, who has boldly and repeatedly declared to customers, investors and the company's own employees that:

It is in keeping with those tenets and our embrace of the United Nations' Sustainable Development Goals (SDGs) that we are accelerating our drive to help materialize sustainability for societies around the world. I believe that helping to resolve social issues through business is vital to corporate prosperity. Companies that fail to help bring SDGs to fruition can never survive. We will accordingly endeavor to enhance our businesses and management from financial and from environmental, social, and governance perspectives.

Isabelle Kocher, CEO of Engie, struck a similar tone when she made her case for moving the leading French energy business toward a renewable energy model and extending her company's CSR ambitions to its full supply chain. "Can a company ignore the overall impact of its activities and hide behind the pursuit of profit alone?" writes Kocher in a recent article. "I believe that the fortress company model, deaf to the expectations of its wider environment, is doomed to disappear under the pressure exerted by four figures: the consumer, the employee, the regulator and the investor."

Not only have C-level executives stepped up their commitment to sustainability within their own organizations, but many have increased their engagement with various advocacy groups in order to bring about broader change within their industries.

When it comes to what we call the Systemization stage, a leading flavoring company rolled out a new business strategy, developed in conjunction with the company's stakeholders, that is fully aligned with the SDGs and extends its sustainability vision beyond 2030. To execute against the strategy, the company took a very different path than many organizations and decided to integrate procurement and sustainability into one function.

With strong support for their efforts from their CEO, the newly integrated, multifunctional team saw strong stakeholder engagement as being a key enabler of the strategy and as a driver of change across their industry. To make it happen, they stepped up engagement with various core organizations, most notably the CEO-led World Business Council for Sustainable Development (WBCSD), which is galvanizing leaders across industries to take bold actions to transform their organizations. The flavoring company believes that organizations such as the WBCSD are critical due to the robust engagement and conversations being held there. Being CEO-led and high-level, new initiatives can move along quickly, such as accelerating transformational change in global food systems.

Having strong support and active engagement from the C-suite is imperative if you want to see real change in adopting a sustainable business model. The SDGs themselves prove to be a very useful tool for heightening senior executives' awareness of the positive potential of adopting sustainable business models and then getting them to commit to concrete actions.

Other high profile stakeholders and industry associations have also successfully leveraged the SDGs to encourage better engagement from senior executives. Many of

the sustainability executives we spoke with emphasized that a highly effective way to develop their CEO and other C-suite leaders' thinking is to have their executives to attend and become involved with UN or industry-led events and initiatives. Direct contact with others that are pursuing these initiatives is the best way to create excitement around the concepts and opportunities and make obvious the risks of not responding to changes in the market and their own industry. If organizations are looking to get started in their transition or move to the next stage, these types of C-level engagement opportunities are an important place to start.

Helping employees to understand sustainability

Most of the companies we interviewed readily admitted that one of the biggest challenges in moving their businesses toward sustainability is in skilling up their workforces to take on this significant challenge. Most large organizations have highly skilled CSR or sustainability departments. Sustainability-focused team members are highly knowledgeable about the field and well connected into the expanding professional community. But we believe that those parts of the organization are generally too small and, often, detached from other functions within the business.

It was apparent in our survey of multinational, SMEs and start-ups that most sustainability departments are understaffed. The highest number of people we encountered in a single company's sustainability department was 25—and this was in an organization of nearly *100,000 employees*. Typical companies had one to five people staffing such departments. Organizations will therefore have choose to either significantly scaled up in size their dedicated sustainability teams, or to be implement a broad and deep training effort to skill-up employees throughout the organization.

To do so and drive success, businesses need to figure out how to generalize knowledge about sustainability across their organizations. Having champions that can encourage—and even inspire others to wholeheartedly join the effort—is essential to driving any change management program. But how do organizations find and build talent that will be able to execute on the increasingly ambitious sustainable strategies championed by the C-suite?

When it comes to driving a sustainability program, a topic with which employees in businesses of all sizes are typically unfamiliar, companies are unlikely to experience success by appointing someone to be the champion just "because it's their time," or for some other commonplace reason that companies give to assign roles. Because sustainability, as a relatively new field, still has many vague elements, the best way forward is to let potential employees come to you: Interest rather than extensive experience should be the priority for hiring these types of roles.

This is how a Vice President of Sustainability at a major chemicals company we spoke with, came to their role. Roughly 10 years ago, their CEO decided that the health, nutrition, and materials business had to expand its commitment to sustainability after a discussion with a major international humanitarian organization. Soon after senior leadership at the parent company communicated to each business that they were required to appoint a head of sustainability.
When the now-vice president heard the new directive, they were Head of Strategy for one of the business units. They said that they immediately put their hand up as they

felt their role already was to take care of the intangible value in the business. They saw sustainability as potentially part of this intangible value of the business, and that the company's contribution to society and the environment could have intangible value in terms of what the brand stands for and what the organization is capable of. Ten years on, with the help of such responsive and likeminded employees, the company is seen as one of the leading large businesses on the topic of sustainability.

A Wealth of Sustainability-focused Education

Many of the people who will ultimately be tasked with building and managing the sustainable businesses of the future have yet to join the companies that are looking to make such an effort. The good news is that many younger people, who desire to work for sustainable companies at much higher numbers than ever before, already have the mindset, motivation and passion for sustainability to drive real value once they join businesses.

More, too, are being exposed to the concepts behind sustainability than ever before. Various initiatives around the world are introducing sustainability as a fundamental value to youth around the world. For 15 years during the application of the Millennium Development Goals, UNESCO supported the Education for Sustainable Development program, which was implemented at all age levels in schools across the world.

UNESCO promoted ESD to empower "learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity." The goal was to raise a generation of citizens that would contribute to society from a position that fundamentally viewed all their actions from the perspective of sustainability.

Calliope Learning in the United States has launched TeachSDGs, an initiative designed to build awareness of the SDGs and sustainability via project-based learning that starts from an elementary-school level. The TeachSDGs team expressly encourages teachers to be active participants in the effort and empower their students to take action on the goals, in order to further expand knowledge of the SDGs. Technology is a powerful tool for TeachSDGs to achieve the organization's goals, and the group explores platforms that can be catalysts for teachers and students to accelerate and succeed in their efforts.

"We partner with a lot of educational technology companies, because they seem to be the groups that are highly motivated to find ways to bring the global goals to classrooms," says Jennifer Williams, co-founder of TeachSDGs. "At the elementary level, educators are seeking ways to use technology to support students to take action on the goals. So they'll have them create digital stories, or they'll use video conferencing."

One group that Williams is working with, for example, is called Empatico, a digital platform from the nonprofit arm of the Kind Snacks, who make healthy treats. The relationship is mutually beneficial, an exchange of technological know-how for insights on sustainability.

"Empatico have a goal of connecting one million elementary students by the year 2020 through video conferencing, all around the topic of empathy. They have eight lessons, and we're starting with 150 global educators, with a goal of getting 3,500 educators by 2020," Williams explains. "They've now taken the lessons, through working with members of TeachSDGs, and they've aligned them to the goals."

Lifelong learning will also be a strong element of practicing sustainability. Knowledge and best practices in the field are continuously evolving. Without many generally agreed standards and frameworks for success in the field, this is even more so the case. Companies will need to identify platforms that can offer their employees opportunities to regularly update their skills in this area and adapt their work as required.

Fortunately, there are a growing number of entities, including the UN Global Compact, the UN University, online learning platform edX, and many others who are offering a regular stream of content and, in some cases, online tools to help employees hone their skills. Companies will want to find ways to repackage this content and pull in other learnings they've gained along the way to identify knowledge and capability-building approaches that best suit their organization.

Conclusion

The SDGs are a rallying cry that is inspiring organizations, particularly large ones, to act. Businesses have taken many positive steps toward aligning their current activities with these 17 goals, including in both their operational activities and their CSR and philanthropic endeavors.

However, alignment isn't action, and there is still far to go before sustainability becomes core to business organizations. This is a journey that companies are on and no one has mastered it yet.

To move the needle on transforming a company to a sustainable business model, a vital area for companies to focus on is their internal talent and messaging around sustainability. Organizations that showed real progress in the sustainability journey have executives and sustainability officers that are aligned and able to convey meaningful and comprehensible messages across the organization. This in turn allows them to identify and empower staff who are best suited to train up on sustainability concepts and champion them on the ground level of the business.

And, by doing so, these companies make it possible to attract the kind of employees they need today, ones who not only are trained on sustainability as a fundamental part of their business education but have become much pickier about for whom they work.

Combined with a focus on measuring performance against the SDGs, an organization that thinks hard about its staff and its internal messaging has the possibility of staying competitive in a rapidly evolving market.

Contact email: donald@readtheair.jp

Study of Façade Treatment for Optimum Daylight Usage in Open Plan Offices in Context of Dhaka

Adeeba Ahsan Amina, Primeasia University, Bangladesh

The Asian Conference on Sustainability, Energy and the Environment 2019
Official Conference Proceedings

Abstract
Electricity consumption is the highest energy drainer when it comes to artificial lighting used in offices even though maximum office-hour coincides during the day time. Although few simple design inclusions in the initial phase of designing can reduce electricity consumption as well as add bonus effects such as physiological and psychological improvement through use of daylight, it is still neglected due to lack of awareness and negligence. Even if not included in the design phase, simple design modifications might change the scenario altogether. Proper daylight use can be of economic and health benefit. The author aimed to evaluate on the use of solar panel louvers in existing buildings to avoid glare from excessive daylight and its optimum utilization in open plan offices in context of Dhaka. To achieve this, it required field survey, questionnaire survey, user satisfaction interviews, background study and software simulation. Daylight simulation has been performed by producing the virtual urban environment based on the survey of a true site urban office building located in Dhaka, Bangladesh. Through software simulation Climate based daylight modelling has been done using Ecotect, RADIANCE- based DAYSIM. It was made possible to assess possible solar panel louver options with varying angles, that would provide optimum Daylight use and help reduce unwanted glare as a more sustainable option. ECOTECT is used as a modelling interface to launch the DAYSIM program. For a sustainable building design, general methodology and information provided in this paper will accompany in future scope of research and implementation.

Keywords: Daylight Use, Open Plan Office, Ecotect Simulation, Solar Panel Louver, Sustainable

iafor
The International Academic Forum
www.iafor.org

INTRODUCTION

Open office spaces are becoming a beneficial trend in the commercial sectors due to the scope of its resource sharing, space flexibility and interactive environment. As open plan provides much flexibility of space usage it also means that much of the daylight, if façade treatment is done properly, can be used by most of the daily users. Lack of partitions maximizes the use of daylight to the maximum of the spaces. Proper use of daylight is going to have a huge impact in the amount of energy consumption with the help of better improvised ideas and statistics for using it in offices.

Many options are available for preventing solar heat gains, excessive glare from abundance admittance of daylight in modern building offices with glass facades. Some of which are cost effective but tedious to maintain, automated but costly to maintain. Options such as manual or automated blinds are quite common and on-the-go solutions for such situations. Although automated solar shading can be a cost effective and sustainable solution in the long run usage of the building. Automated shading will be helpful in operating as it will adjust itself in accordance with the sun path and generation of electric power will be supplementing its operational power needs.

There are many variables of solutions available for optimum daylight use but the ultimate goal of these design solutions are user satisfaction in work places and to provide optimum illuminance level which is 300lux Standard for Office work and desk level works (Joarder M., 2009)

Although proper daylight usage through improvised solutions are available but it is not advisable to come up with design solutions later after completion of building design rather during the initial design phase any building should be designed by considering such vital factors which has negative impacts on energy consumption, user comfort and well-being. Specially in office places where people spent most of their vital time of the day inside, losing health and mental balance.

1. Literature Synthesis

The criteria of visual and thermal comfort, productive and sustainable use of power consumption defines a well-designed office which are directly related to as well as can be achieved by successful use of daylight. Visual comfort is very important for well-being and productivity of the occupants in buildings (Leech et al., 2002; Serghides et al., 2015). The effect of visual comfort on occupant work performance, productivity, comfort and satisfaction can be assessed from many past studies where natural light plays a vital role in physical and therapeutic ways (Veitch, 2001). Visual comfort defines lighting conditions, even distribution of light, prevention of excessive glare and optimum light level ambience. Insufficient light and especially daylight or glare reduces the ability to see objects or details clearly (Leech et al., 2002). Architectural design has a direct impact on office lighting and office lighting has a direct impact on well-being and productivity of the users. The access to natural lighting as well as artificial lighting is essential in order to ensure well-being of occupants in areas where natural lighting is missing or during evening when the natural lighting fades (Aries et al., 2010).

Visual comfort at work has an impact on comfort after work as well. Open plan offices have negative effect on visual comfort which leads to a negative impact on occupant as well. Visual comfort plays such a vital role in the overall productivity, comfort and well-being of the occupants that buildings need to avoid excessive use of artificial lighting yet still maintain some level of optimality (Yun et al., 2012). Therefore, one needs to study daylight, artificial lighting, glare and visual comfort together in order get a more sustainable design in resource as well as occupant comfort.

1.1 Statement of the problem

It is a common practice in offices to use artificial lighting even though maximum office hour takes place during the day time. Electricity consumption is the highest energy drainer when it comes to artificial lighting used in office spaces. Even though few simple design inclusions in the initial phase of designing can reduce electricity consumption as well as add bonus effects such as physiological and psychological improvement through use of daylight, it is still neglected due to lack of awareness and negligence. Even if not included in the design phase, simple design modifications might change the scenario altogether. Proper daylight use can be of economic and health benefit.

1.2 Aim and objectives

Aim

The author tried to come up with a comprehensive study of the benefits and efficient use of daylight in open plan office space by thorough analysis of primary and secondary data sources. With proper deduction and simulations, it can be ensured that daylight use will eventually reduce pressure on electricity consumption and benefit the users on physiological and psychological levels.

Objectives

- Analysis of current indoor luminance quality to understand the existing scenario.
- Comparison with Standard requirement with the existing situation and the design best solution to achieve the desired effect.
- Determine the effects of daylight inclusion along with interior finishes and elements such as- floor finish, furniture tops, ceiling height, window configuration and relevant items, as such.
- Determine the effect of daylight use in economic, physiological and psychological parameters for user satisfaction.
- Software simulations to determine the feasibility of hypothetical solutions.
- Analyze and draw conclusions from the simulations of the overall impact of daylight for office work efficiency.

1.3 Scope and limitation of the work

Scope

The study provides opportunities for considerations of façade treatment inside and outside of a building in more sustainable ways with variable aspects as of solar panels.

Limitation

If compared with other variant or simultaneously work with another variant could make some result or approach of the study less sustainable.

Constraints like time limit is a huge factor, since only one office's performance was considered for drawing conclusions.

2 Research Methods

Dynamic Simulation is the main research method selected for this study. The flow chart below explains the process:

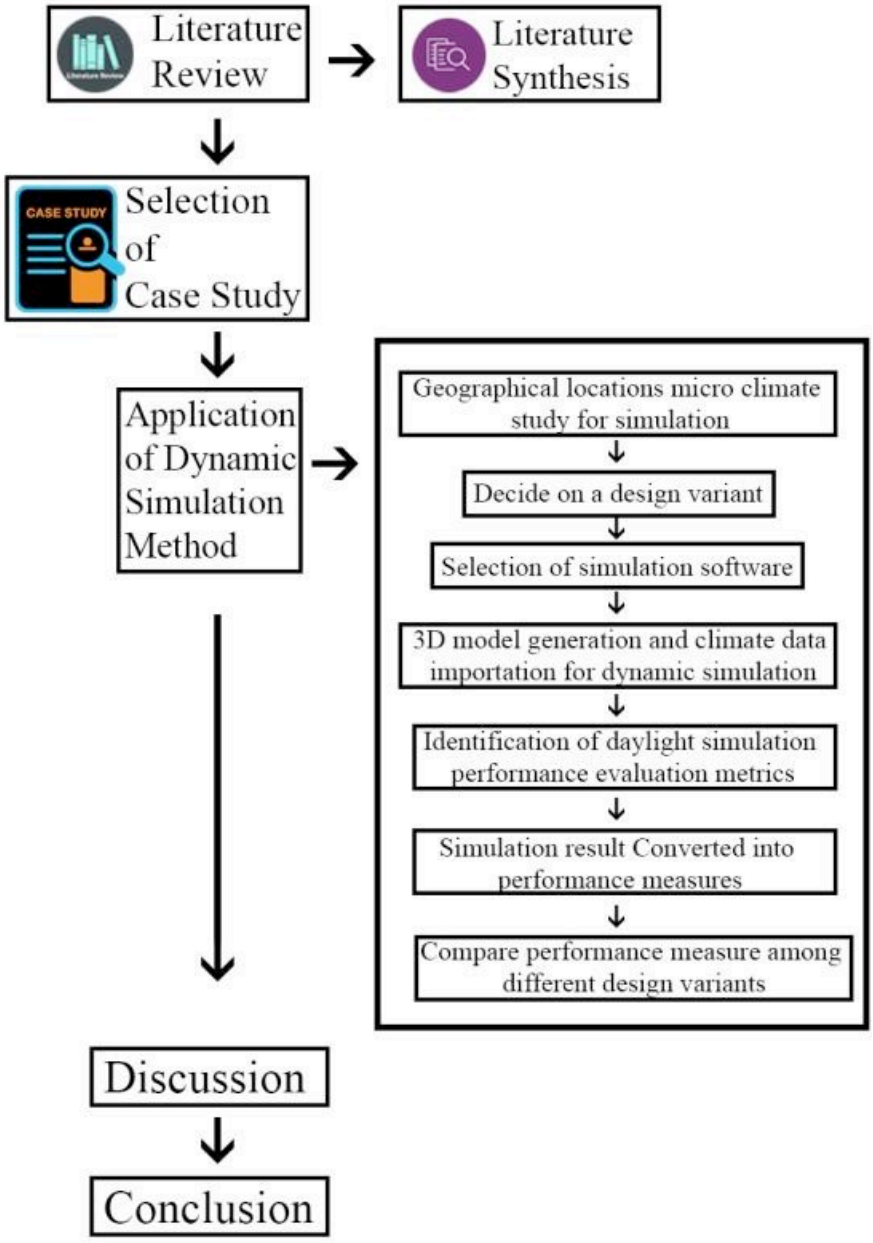


Figure 1: Flow diagram of the simulation process (after Rahman, H. 2018)

3 Case Studies

3.1 Selection of Case Study

For the purpose of this simulation study, an open plan office building was selected with glass façade on maximum sides. Simulations were done considering the surroundings of the site.

- **Location:** House 37, Road 11, Block H, Banani, Dhaka 1213, Bangladesh.

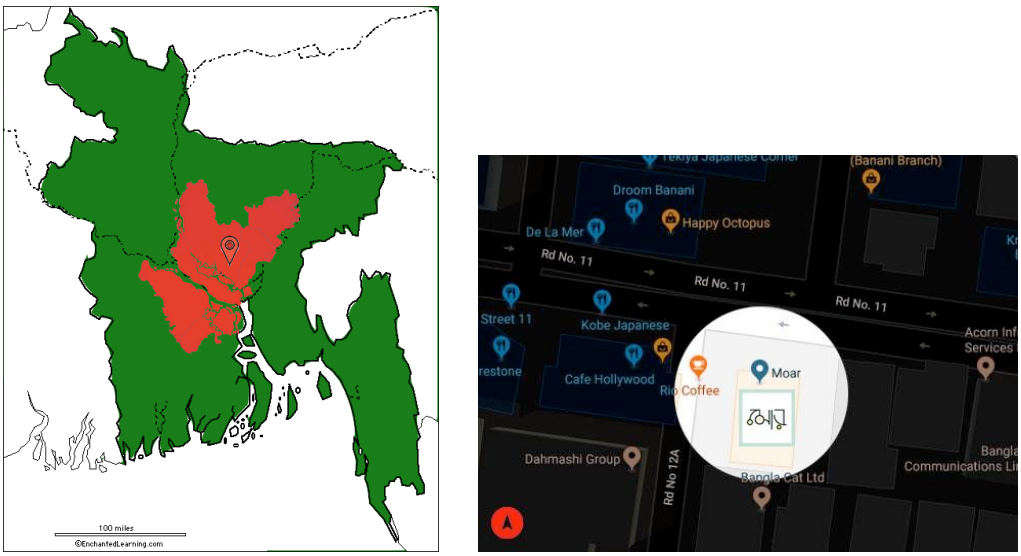


Figure 2: Location Map of Office "Moar"
Source- Google Maps

- **Zone type:** Mixed Use Zone of the "Posh" area of Banani

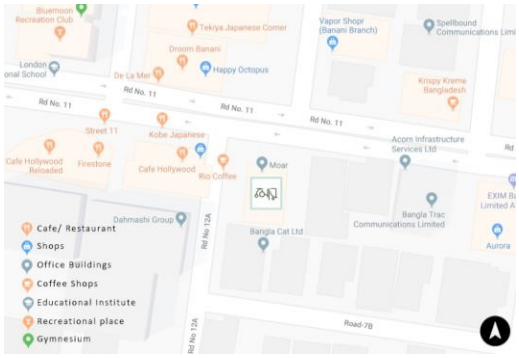


Figure 3: Land Use Map | Source- Google Maps

- **Office Plan Layout:** Open plan

Figure 4: Office Floor Plan | Source- Author

(a) (b)

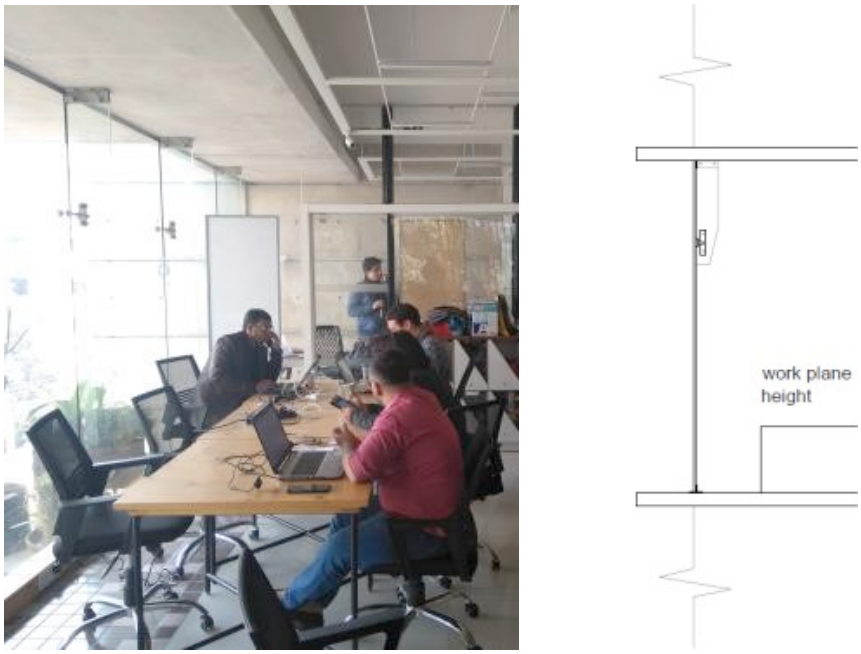


Figure 5: Images- (a) South side of the Office allowing excessive daylight, (b) Existing Window Section | Source- Author

4 Application of Dynamic Simulation Method

This section describes application of the simulation methods. Simulation is done to make the decision about the configuration of skylight influencing light inside the open plan office structure. To complete this stage, the author has gone through the steps that has been shown in above diagram (Figure 1). Others steps described in detail, below:

4.1 Geographical Locations Micro Climate Study for Simulation

Dhaka has tropical climate and three distinct seasons. Those are the hot-dry (March-May), the hot-humid (June-November) and the cool-dry season (December-February) (Ahmed, K. S., 1995). Throughout the hot-dry or summer, the sky can remain both clear with sun and overcast. During monsoon period which is hot-humid, the sky remains significantly overcast at most of the time. During the winter which is cool-dry, the sky remains typically clear. Composite climates as Dhaka, where mutually overcast and clear conditions are experienced during the course of every year. This guides designers for the suitable daylight enhancing solution (Ahmed, Z. N., 1987).

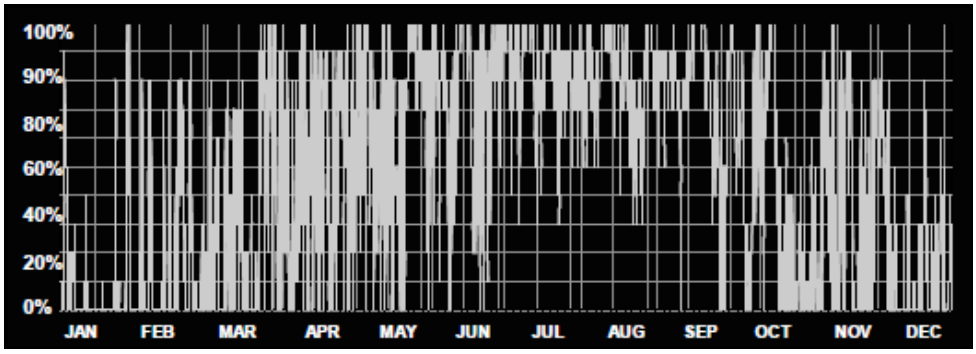


Figure 6: Cloud cover for TRYs, Dhaka (Source: U.S. Department of Energy [61])

4.2 Decide On a Design Variant

During site survey, Solar panel louvers seemed more logical and sustainable, considering visual and thermal comfort, productive and sustainable use of power consumption. As it is a commercial building, one successful application of solar panel louvers will encourage others to do so.

Solar panel louvers come in many combinations of shape, size, finish, frame and installation details. Solar panel louvers can use transparent or translucent finish, in glass or polymer of various configurations to achieve the goals of even light distribution, glare prevention and solar control. (Mestek Architectural, 2012)

A variety of solar panel louvers exists for applications on exterior façade.

(a) (b) (c)

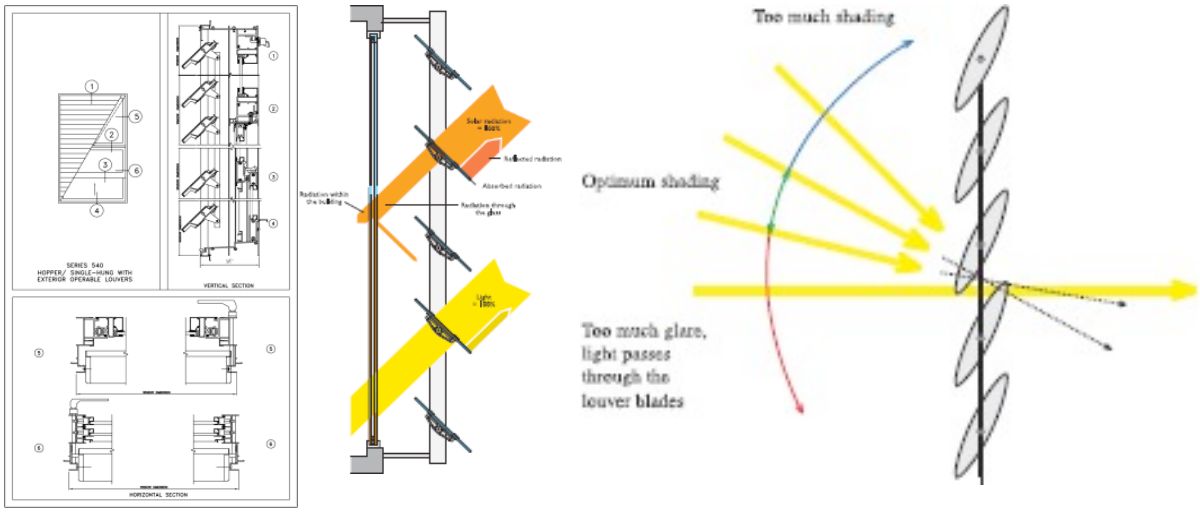


Figure 7: (a) Solar Panel type, (b) Solar Radiation & Light interaction with the Panel, (c) Image showing different angles' situations

Figure 8: Image of the Shadovoltaic panels and its features | Source- MESTEK Architecture(2012*)*

4.3 Software Used for Simulation

AutoCAD, Ecotect, RADIANCE and DAYSIM are the software used for whole simulation process. AutoCAD has been used to produce 2D diagrams, 3d modeling has been produced in Ecotect. For further depth simulation RADIANCE and DAYSIM has been used. Both RADIANCE and DAYSIM have been authenticated widely and successfully for daylighting analysis (Joarder, A.R., n.d) Ecotect also used for running Radiance and Daysim.

4.4 3D Model Generation and Dynamic Simulation Parameters

Physical survey data

- Total floor area: 193sqm Usable space: 182sqm Service area: 11 sqm
- Ceiling: Plastered concrete ceiling painted white Internal wall: Glass Partitions (transmittance- 0.8) Floor: Tiles (reflectance: 0.3)
- Glazing: Double Glazed floor-to-ceiling windows/ façade

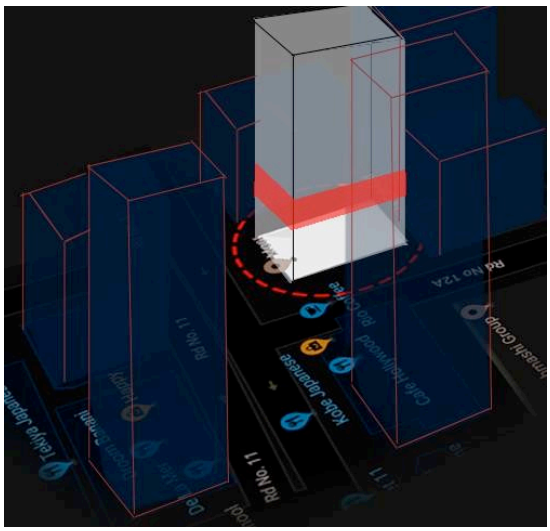


Figure 9: Office building(case study) | Source- Author

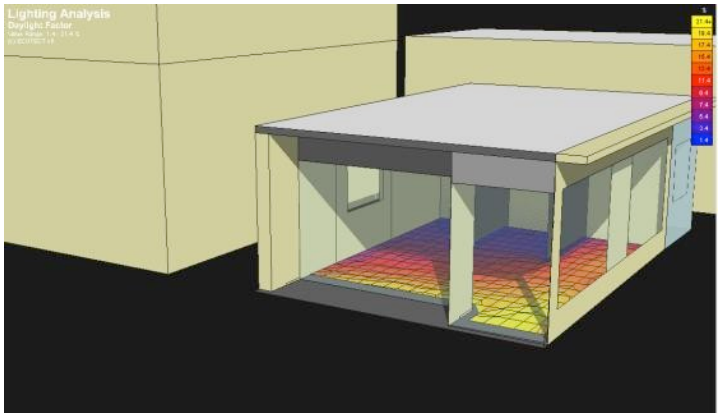


Figure 10: Ecotect Model of the Office Floor showing the existing luminance condition | Source- Author

The Office has glass façade on the South and East side which provides abundance of daylight but at the same time excessive glare. The image below shows the level of daylight entering the office.

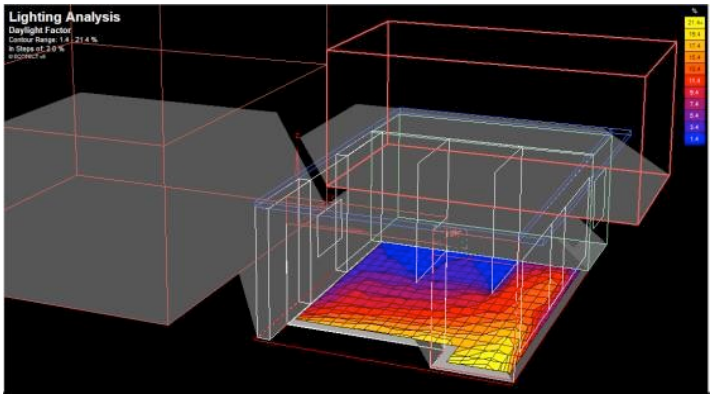


Figure 11: Ecotect showing Daylight level inside the Office | Source- Author

Shadovoltaic Solar panel louvers will not only control the daylight entering the office but will generate and store energy required to run the automated panels. Automated panels make it easier with maintaining the panel angles in accordance with the Sun angle.

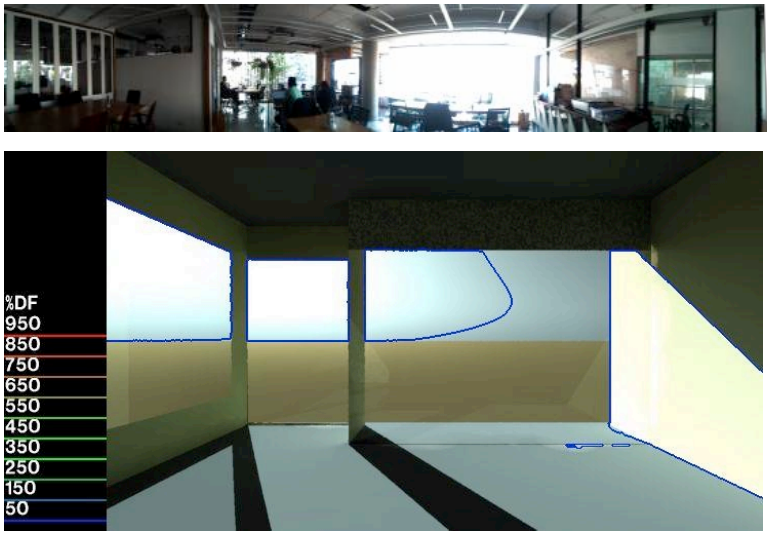


Figure 12: *Above*-Existing South side image of the Office, *Below*- Ecotect Simulation image | Source- Author

The assessments for the daylight simulation were based on the following parameters:

- Location: Dhaka, Bangladesh (longitude: 90.2 deg; latitude: 23.5 deg)
- Local terrain: Urban Ground reflectance: 0.2
- Time: 9.00 am – 5.00 pm Window (dirt on glass): Average Design illumination: 300 lux
- Dynamic sky model: Perez sky model Duration for dynamic simulation: Month of January

(Joarder, A.R., n.d)

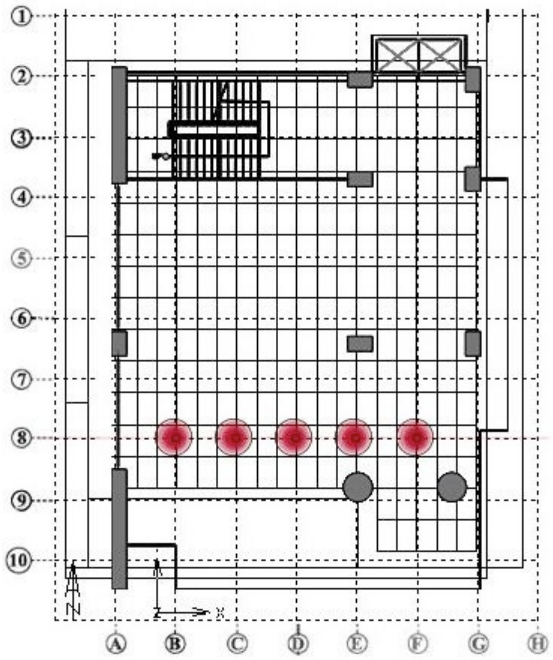


Figure 13: Plan showing the column/structural grid with node references | Source- Author

4.5 Identification of Daylight Simulation Performance Evaluation Metrics

The findings of simulation are evaluated based on the following dynamic performance metrics done with Daysim to get an overall annual understanding

- **Daylight Factor (DF): It** is the ratio of the light level inside a structure to the light level outside the structure. It is defined as: DF = (Ei / Eo) x 100%
- **Daylight Autonomy (DA):** It is the percentage of the occupied times of the year when the minimum illuminance requirement at the sensor is met by daylight alone (Joarder, A.R., n.d).
- **Continuous Daylight Autonomy (DAcon):** The percentage of the minimum illuminance requirement met by daylight alone at the sensor during the full occupied times of the year (Joarder, A.R., n.d).
- **Maximum Daylight Autonomy (DAmax):** The percentage of the occupied hours when the daylight level is 10 times higher than design illumination represents the likely appearance of glare (Joarder, A.R., n.d).
- **Useful Daylight Illuminances (UDI):** The aims of UDI are to determine when daylight levels are 'useful' for the user and when they are not. Based on occupant preferences in daylit offices, UDI results in three metrics, i.e. the percentages of the occupied times of the year when daylight is useful (100- 2000lux), too dark (<100 lux), or too bright (> 2000 lux) (Nabil, A., et al, 2006)

About this metrics details with example are described in Joardar, A. R. "Climate Based Daylight Modelling and Dynamic Daylight Performance Metrics for

Sustainable Building Design in Bangladesh" research paper.

4.6 Performance Measurements from Simulation Results

Ecotect simulation showing the existing sunpath, daylight level condition and the 3 solution options. The images are shown below:

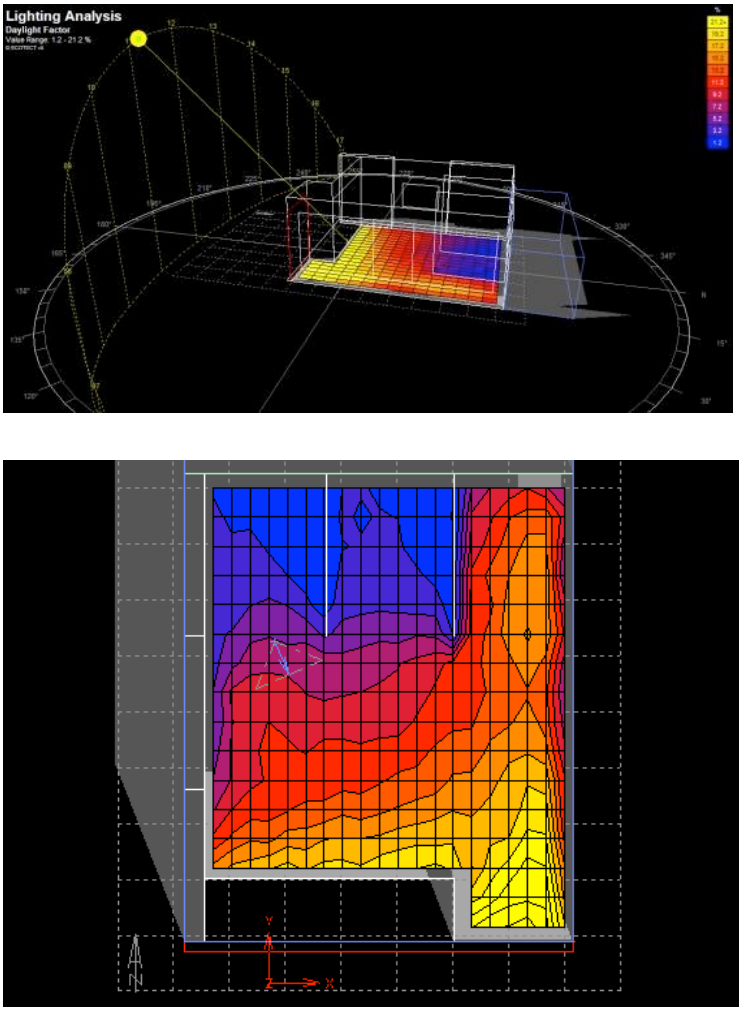


Figure 14: Sun Path for simulation & Ecotect Daylight level intensity | Source-Author

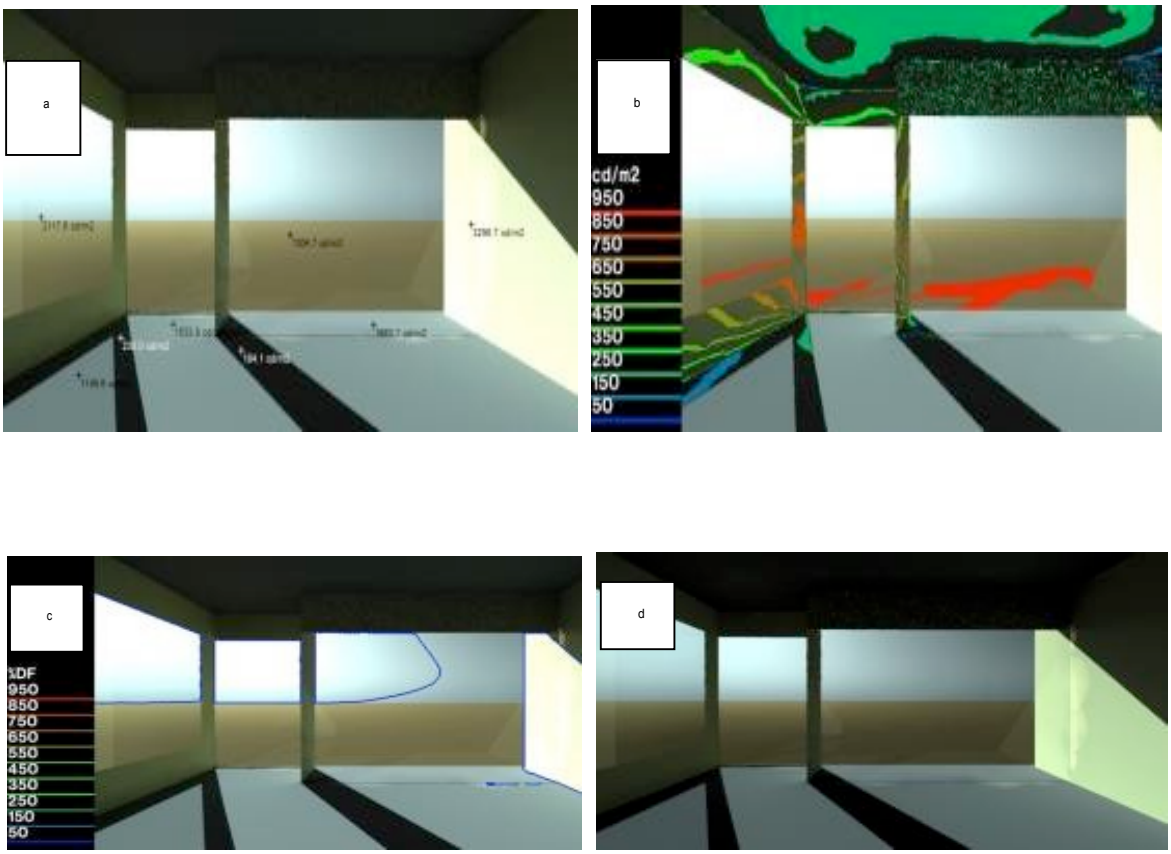


Figure 15: (a) Lux Intensity (b) Contour Bands (c) DF% (d) Human Sensitivity | ***Source- Author produced via RADIANCE simulation***

Possible Solutions of Louvers

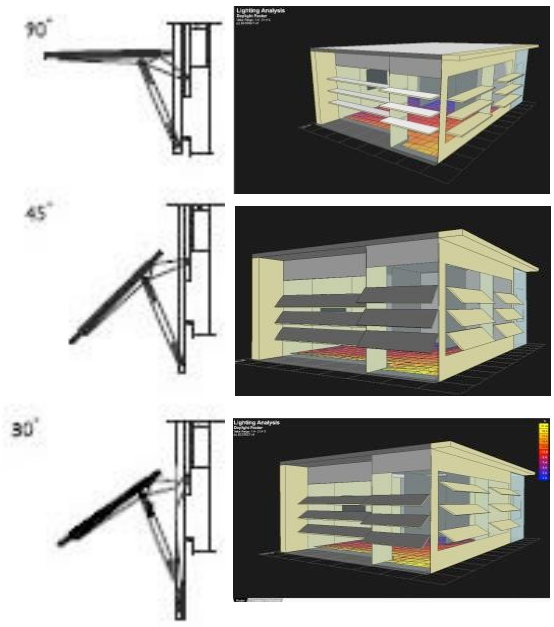


Figure 16: Louver Options- Solution:1 | Solution:2 | Solution:3 shown respectively Source- Author

5 Simulation Studies

The table below summarizes the performance metrics of Panels on indoor daylighting level:

Table 1: Simulation results for three solar panel louvers at different angles Source- Author

Lighting Configuration	(Existing) %	Sol_1 %	Sol_2 %	Sol_3 %
DA %	100	99.95	99.85	100
DA max % UDI<100	87.10	63.850	16.250	32.250
UDI % 100-2000	2.15	15.45	42.85	29.8
UDI >2000	97.35	84.45	56.85	69.7

Table 2: Ranking Metrics of the Three Solutions Compared with the Existing Condition | Source- Author

Type	(Existing)	Solution_1	Solution_2	Solution_3
DA	4	3	2	4
DA max	1	2	4	3
UDI 100-2000	1	2	4	3
UDI >2000	2	4	3	1
Total Rating	8	11	13	11
Place	3rd	2nd	1st	2nd

6 Result

From the readings of the DAYSIM analysis report, final result from the core points of the work plane has been shown in the tables above. It can be seen that Solution- 2 came 1st through ranking system.

7 Discussion

7.1 Solar Panel Louver Configuration:

Soltuion-2 seems to be the best Louver option as the simulation result shows that even though its DA (99.85%) is lower than the rest, the other factors such as DAmax, UDI100-2000, UDI>2000 is at desired level than the rest.

7.2 Solar Panel Louver Features:

Figure 17: Features of Shadovoltaic panels | Source- MESTEK Architecture (2012*)*

Such features as the solar shading property, generation of electrical power are preferable for sustainable daylight use design solution elements. Solar shading would mean reduction of unwanted glare, even distribution of daylight and generated power can be used for driving the sensors o f the automated solar panel louvers.

CONCLUSION

Daylight can be a great source of passive energy, supplementing electricity consumption. Thus resulting economic efficiency. Statistics have also showed the beneficial factors of daylight use on users mental and physical health (Yousef Al horr, 2016). Through proper analysis of simulations, modifications can be made in existing offices to make efficient use of daylight. The author aimed to emphasize on the efficient use of daylight to improve indoor illumination and work efficiency. Through simulations of different modification propositions, these design strategies might give scope for further modification ideas and act as a general guideline regarding daylight usage and indoor luminous environment of offices in Dhaka's context.

Acknowledgements

The study had been conducted to produce a term end paper under the supervision of Dr. Ashikur Rahman Joarder, course tutor of "Luminous Environment and Built-Form (Course code- ARCH 6103)". I gratefully thank him for his persistent guidance and encouraging way of teaching at every step. I convey my heartfelt gratitude to Architect Tamanna Feeroz who assisted me with data analysis.

References

Journal article

Bangladesh. *Global Built Environment Review (GBER)*, 5-22
Joarder, D. M. (2007). Climate Based Daylight Modelling and Dynamic Daylight Performance Metrics for Sustainable Building Design in Bangladesh. *Dynamic Daylight Simulation for Sustaimnable Design*, 21.

Joarder, M. (2009). A Survey on Daylighting Potentiality in the Offices of Dhaka
Yousef Al horr, M. A. (2016). Impact of indoor environmental quality on occupant well- being. *International Journal of Sustainable Built Environment*, 11.

Book

Koenigsberger, O. H. et al, (2012). Manual of Tropical Housing and Building: Climatic Design. India: Orient Longman Private Ltd.

Chapter

Koenigsberger, O. H. et al, (2012). Daylighting. Manual of Tropical Housing and Building: Climatic Design. India: Orient Longman Private Ltd., 141-147.

Internet Document

MESTEK Architectural, (2012). Solar Shading Louver Systems[online].Source. MESTEK Architectural, Intelligent Envelops: http://www.rcs-india.in/catalog/20 Solar%20Shading.pdf [Accessed 09 March 2018].

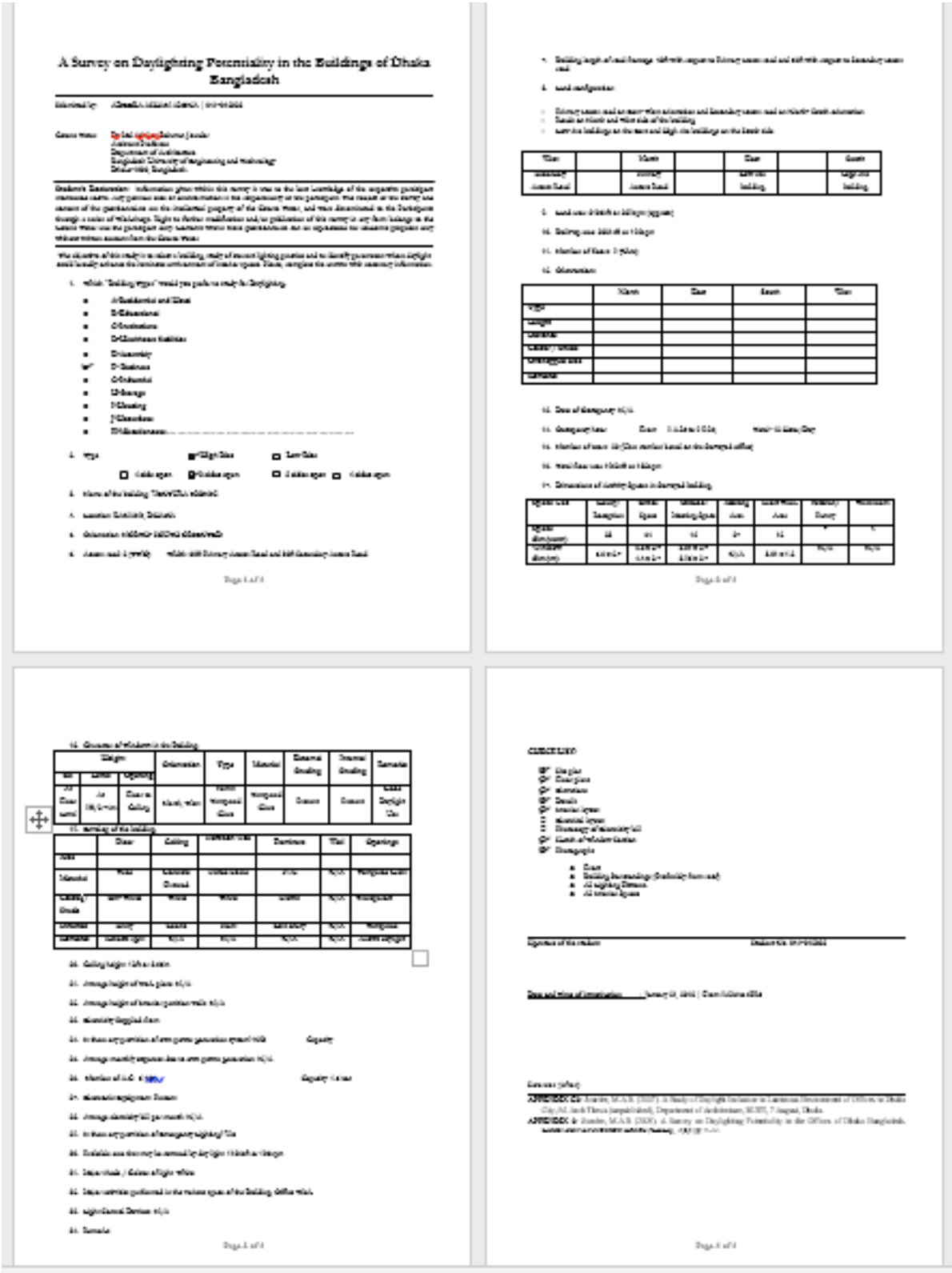
Thesis

Iqbal, MD. N., (2015). Incorporation of Useful Daylight in Luminous Environment of Rmg Factories by Effective Use of Skylights in Context of Dhaka. Thesis (M.Arch). Bangladesh University of Engineering & Technology.

Contact email: archist.aaa@gmail.com

Appendices

Survey Questionnaire:



A Survey on Daylighting Potentiality in the Buildings of Dhaka Bangladesh

Page 1 of 4

Page 2 of 4

Page 3 of 4

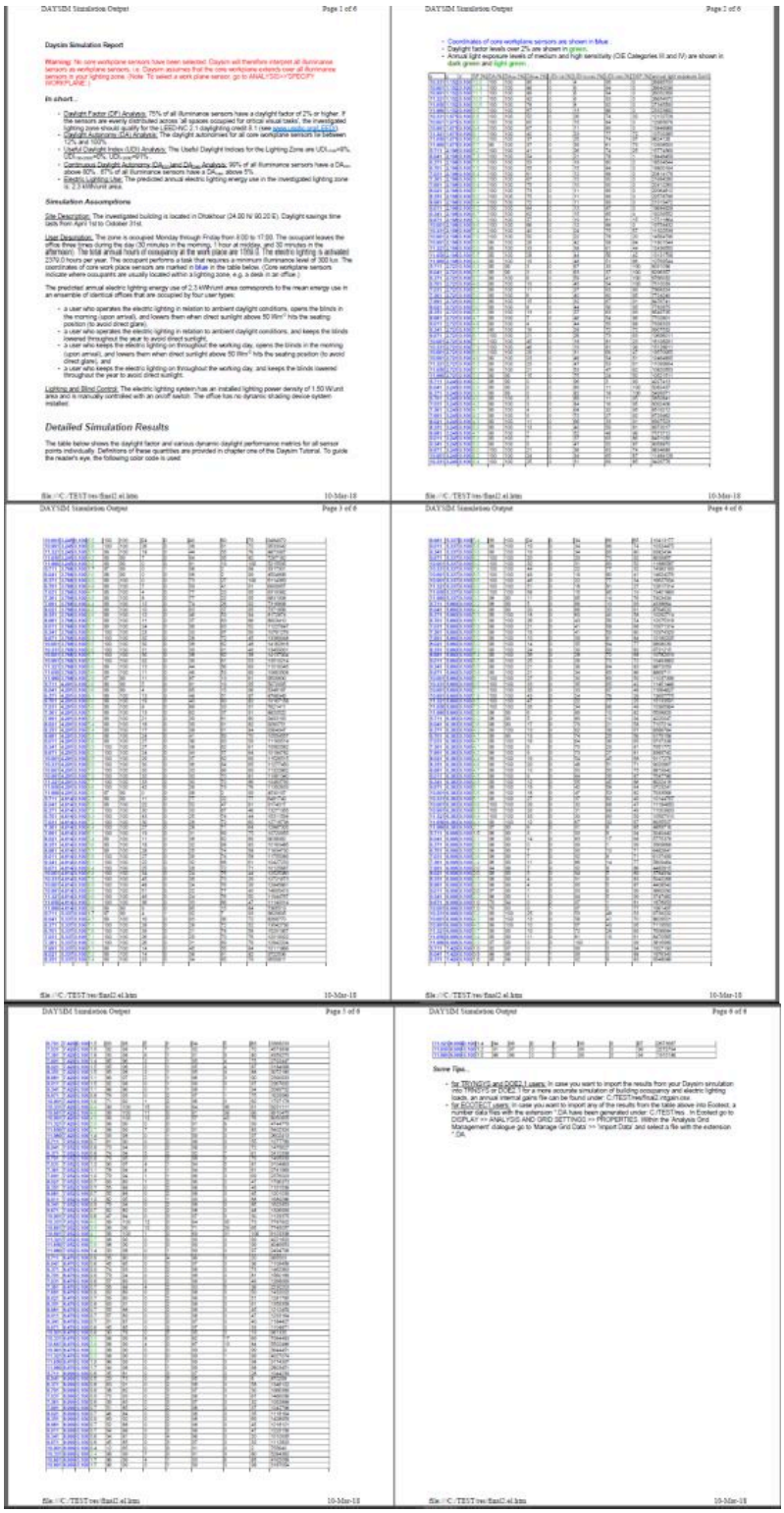
Page 4 of 4

DAYSIM Analysis Reports:

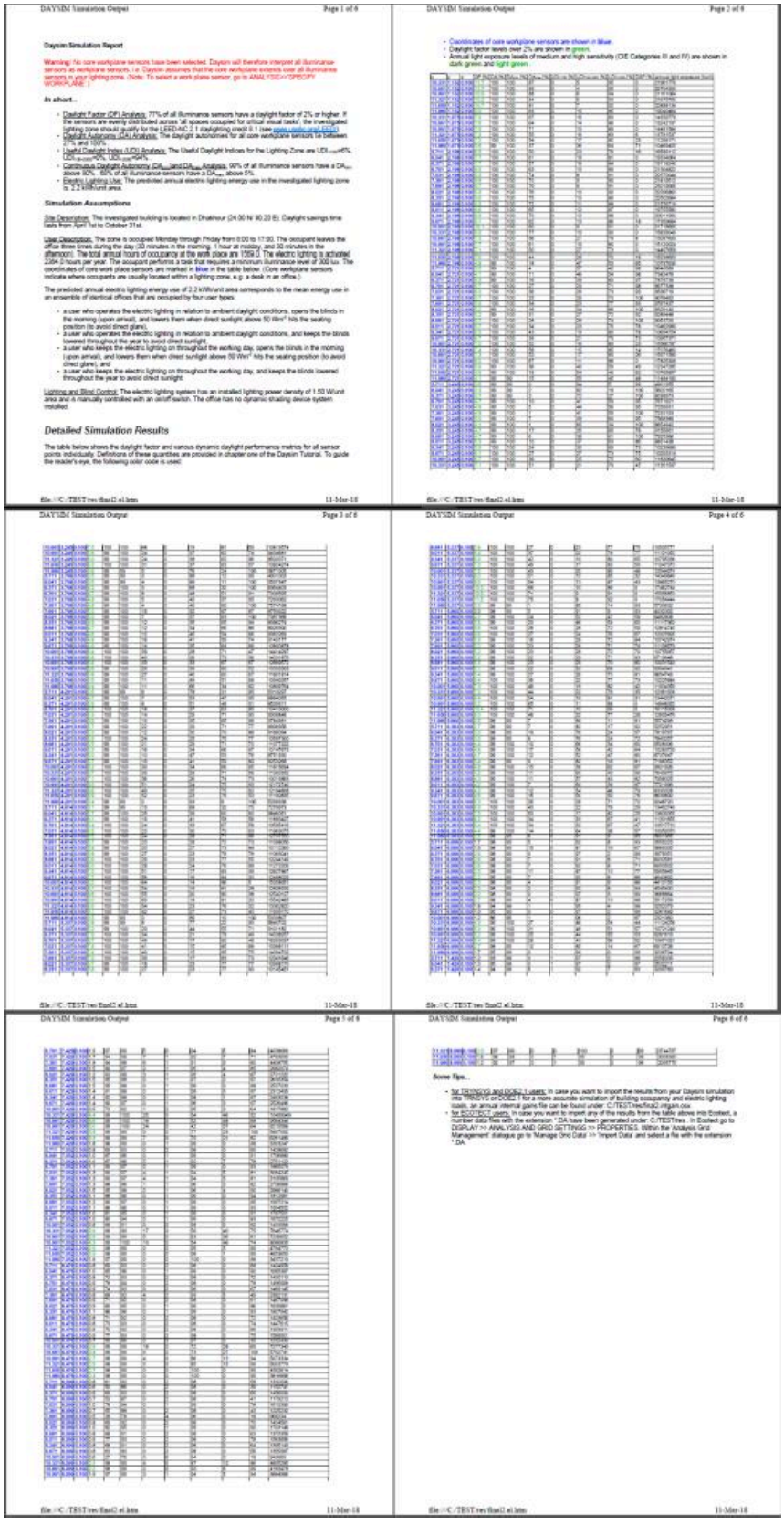
Of Existing Condition

Solution-1:

Solution-2:



Solution-3:



Soil Carbon Contents of Teak Plantation in Agroforestry Farming of Ban Tham Suea, Kaeng Krachan District, Phetchaburi Province, Thailand

Sudarat Chaichalerm*, Phetchaburi Rajabhat University, Thailand
Sureerat Temawat, Phetchaburi Rajabhat University, Thailand
Siriphan Satthaphon, Phetchaburi Rajabhat University, Thailand
Supada Khunnarong, Phetchaburi Rajabhat University, Thailand

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
Increase of atmospheric carbon dioxide is a serious global environmental concern. Teak plantation can store substantial amount of carbon. Soil carbon contents and properties were studied in 3, 6 and 13-years-old teak plantations located in agroforestry farming areas of Ban Tham Suea, Kaeng Krachan District, Phetchaburi Province. Soil samples were collected at 0-30 cm depth by a non-disturbed method from 14 locations. Physical and chemical soil properties including texture, soil bulk density, total nitrogen, available phosphorus, available potassium and soil organic carbon were analyzed. Finding revealed that soil texture as sandy loam, silt and clay loam with bulk density was 1.2, 1.2 and 1.3 g/cm^3 and total nitrogen 0.06, 0.09 and 0.10 % in 3, 6 and 13-year-old teak plantation, respectively. Soil organic matter was the highest at 2.84 in 3-year-old teak plantation, followed by 2.09 and 1.96 % in 3, 6 and 13-year-old teak plantation, respectively. Highest available phosphorus was recorded at 3-year-old teak plantation at 153.08, followed by 6 and 13-year-old teak plantation at 87.88 and 40.90 mg/kg, respectively. Available potassium was highest at 118.01 in 3-year-old teak plantation, followed by 6 and 13-year-old teak plantation at 85.58 and 60.14 mg/kg, respectively while soil carbon stock was highest in 13-year-old teak plantations, followed by the 6 and 3-year-old teak plantations at 37.44, 29.52 and 19.08 tC/ha, respectively.

Keywords: Soil carbon, Teak plantation, Ban Tham Suea Agroforestry

iafor
The International Academic Forum
www.iafor.org

Introduction

Climate change is a recent phenomenon that resulting from the release of large quantities of greenhouse gases (GHG) into the atmosphere. Increasing atmospheric concentrations of carbon dioxide (CO_2) is considered the predominant cause of global climatic change (Jose, S. & Bardhan, S., 2012). Agroforestry refers to the practice of purposeful growing of trees and crops and/or animals, with interacting combinations for a variety of benefits and services such as increasing crop yields, thereby enhancing food security and environmental services while promoting the resilience of agroecosystems (Ajayi et al., 2011). Both agriculture and forestry are combine as integrated agroforestry system to achieve maximum benefits through greater usage efficiency of resources such as nutrients, light, water capture and climate change adaptation and mitigation. The potential of agroforestry systems for carbon sequestration depends on the biologically mediated uptake and conversion CO_2 into inert, long-lived, C-containing materials which a process that called biosequestration (Lorenz, K.&Lal, R., 2014). Teak (*Tectona grandis* Linn f.) has been a principal tree species for timber since the middle of the nineteenth century and commands a high value for its durability, mellow color, and long straight cylindrical bole. Teak belongs to the family Lamiaceae and is grown in plantations in around 60 countries (Reddy et al., 2014). Although native to South and Southest Asia, mainly India, Myanmar, Laos and Thailand, teak is also cultivated in other parts of the world, including in Java, Indonesia. Teak performs well in plantations under favorable conditions and is most commonly found in moist and dry deciduous forests below 1,000 m elevation (Boonyanuphap, J. & Kongmeesup, I., 2016). Primary factors affecting the growth of teak are soil depth, soil texture, drainage, moisture status and fertility. Teak plantations can store substantial amounts of carbon. Most previous studies conducted on agroforestry teak plantations emphasized on estimation biomass, carbon stocks, and the change in carbon stocks in relation to plantation ages, while few correlated age and chemical properties. Soil organic carbon data in equatorial zones are limited, especially in Thailand. Therefore, soil carbon contents and some physical and chemical properties of 3, 6 and 13-years-old teak plantation were studied in agroforestry farming areas of Ban Tham Suea, Kaeng Krachan District, Phetchaburi Province. Incorporation of trees or shrubs on farms or pastures can increase the amount of sequestered carbon compared to monoculture fields of crop plants or pasture.

Materials and Methods

The study area was located in Ban Tham Suea Agroforestry situated about 15 km to the north eastern of Kaengkrachan District and covering 18,786 rai (3,005.76 ha). Phetchaburi province is located north of the Gulf of Thailand and its climate is influenced by southwest monsoon winds. Rainfall data form 2007 to 2017 averaged 86.84 mm/month with average temperature ranging from 21.4°C to 35.7°C. According to the Universal Transverse Mercator (UTM) grid value, the teak plantations were located between 576605 – 577933E and 1420895 – 1422492 N. Elevations of the study sites were about 300 MSL. This study area consisted of mixed tree planting such as rambutan, durian, mangosteen, lime, pineapple, banana, natural forest, vegetable and teak plantation. This agroforestry had the teak plantation area was about 26 rai (4.16 ha) with 434 standing teak trees of all age. Soils in 3, 6, and 13-years-old teak plantation were surveyed. At 14 sample locations, 1x1x1 m^3 pits

were dug to determine the soil profile. Sample pits were selected by considering topography and soil distribution and comprised of four pits for 3-year-old plantations, 9 pits for 6-year-old plantations and 1 pit for 13-year-old plantations (Figure 1). Non-disturbed soil samples were collected at 0-30 cm depth to analyze bulk density (Black, 1965). Particle size distributions were determined by hydrometer method (Blake, G.R. & Hartge, K.H., 1996). Soil sample were air-dried and crushed to pass through a 2 mm mesh sieve to remove roots and other plants and debris before analysis of soil organic carbon by the wet oxidation method (Walkley, A. & Black, C.A., 1934). Total nitrogen was determined by the micro-Kjeldahl digestion technique (Black, 1965). Available phosphorus was determined using the Bray II method (Bray, R.H., & Kurtz, L.T., 1945), and available potassium was analyzed by 1N of ammonium acetate extraction procedure buffered at pH 7.0 using an atomic absorption spectrophotometer (AAS) (Pratt, P.E., 1965). Soil carbon content were determined by a CHN analyzer for carbon content (%), bulk density and soil depth, including calculated carbon stock.

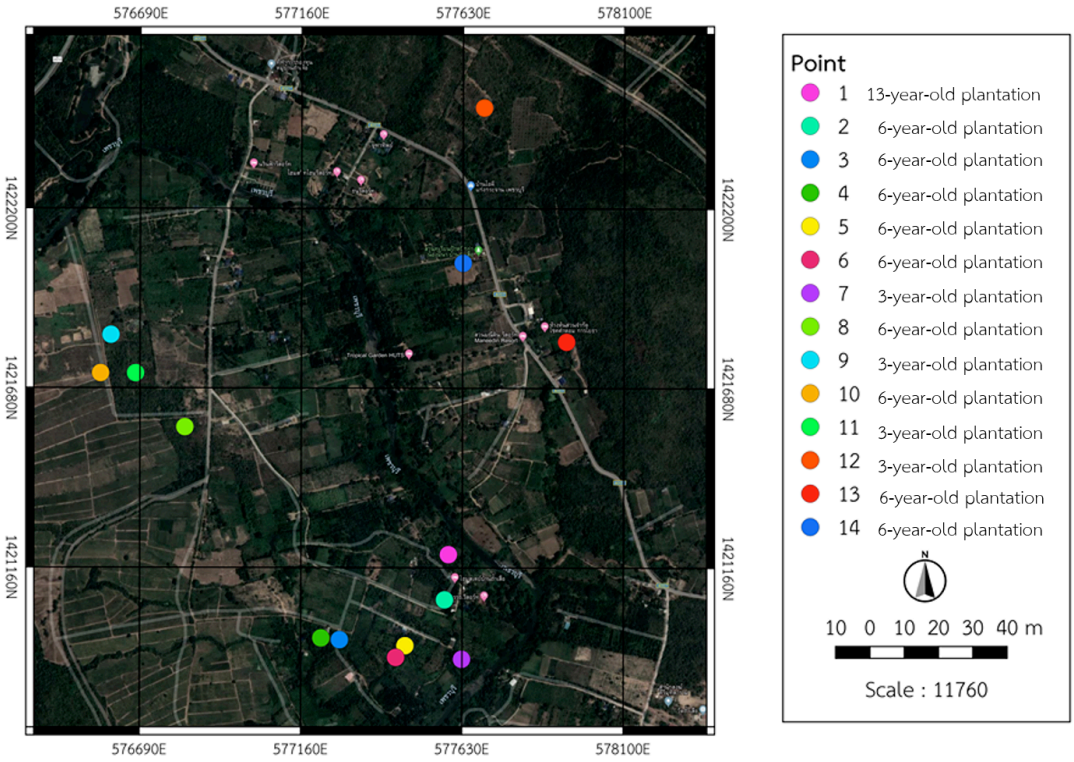


Figure 1: Location of teak plantation sites in Ban Tham Suea Agroforestry.

Result and Discussion

Soil, as a heterogeneous unit, shows great variability in physical, chemical, biological and mineralogical properties. Results for soil texture, bulk density, carbon content and carbon stock for 3, 6 and 13-year-old teak plantations are shown in Table 1. Sand ranged from 36.31-61.87%, silt ranged from 25.53-39.38% and the clay ranged from 12.60-25.79%. Soil texture varied as sandy loam, loam, clay loam and silt loam. Sand particle were highest in 13-year-old teak plantations compared to other soil fractions. This result was attributed to parent materials, climate and land use which influence to pedogenesis and properties of soils. Sandy soils reflect their parent material as coastal

plain sand. Sandiness of soils suggest low carbon exchange capacity and high water infiltration. Silt particle content was low, indicating that most of silt had weathered into clay. Clay particle content of the soils was also low, indicating that vegetation cover may have reduced the rate of water movement and reduced clay translocation (Osujieke et.al, 2018). Bulk density ranged between 1.20 and 1.3 g/cm^3. This result concurred with Sharma, C. (2015) who found that teak plantation in Dimoria Tribal Belt of Assum, India had bulk density at 1.41 g/cm^3.

Soil carbon stock is an important aspect of total ecosystem carbon sequestration as detailed in the Kyoto protocol. Soil carbon stock correlated highly with the ages of teak plantation. Highest soil carbon stock of 37.44 tC/ha was found in 13-year-old teak plantations, while plantations age 3 years had the lowest soil carbon stock of 19.08 tC/ha. This result agreed with Boonyanuphap, J. & Kongmeesup, I (2016) who found that teak plantation in subtropical region of lower Northern Thailand with ages between 35 and 36 years had higher total carbon stock than those ages between 21 and 23 years. Table 2 shows the results of soil organic matter, total nitrogen, available phosphorus and available potassium in 3, 6 and 13- year-old teak plantation. Organic matter and total nitrogen were generally low compared to other studies. Organic matter ranged between 1.96 and 2.84 %. Total nitrogen was low with a range of 0.06-0.10 % compared with critical values (1.5-2.0%) for tropical soils. Nitrogen is a major constituent of all proteins and all protoplasm, causing an increase in leaf growth. Phosphorus is also a vital ingredient for many enzyme reactions that depend on phosphorylation and is necessary for the development of meristematic tissue (Omatayo et al., 2010). Available phosphorus and available potassium was highest in 3-year-old teak plantations, followed by 6 and 13-year-old, respectively. These results were similar to Al Mahmud et at. (2017) who reported that the exchangeable phosphorus and potassium content negatively correlated with teak monoculture plantation age in Bangladesh; younger teak plantations had higher contents compared to older plantations.

Pearson correlation among parameters shown in Table 3. Analysis determined a significant positive correlation between bulk density and total nitrogen, available potassium and soil carbon stock. Similarly, total nitrogen exhibited a significant correlation with available phosphorus, available potassium and soil carbon stock, while a significant correlation was shown between available potassium and soil carbon stock.

Table 1 Average soil texture, soil carbon content and carbon stock in 3, 6 and 13- year-old teak plantation

Plantation age (year)	Sand (%)	Silt (%)	Clay (%)	Bulk density (g/cm^3)	Soil carbon content (%)	Soil carbon stock (tC/ha)
3	36.31	37.90	25.79	1.20	0.53	19.08
6	46.77	39.38	13.86	1.20	0.82	29.52
13	61.87	25.53	12.60	1.30	0.96	37.44

Table 2 Average organic matter, total nitrogen, available phosphorus and available potassium in 3, 6 and 13-year-old teak plantation

Plantation age (year)	Organic matter (%)	Total nitrogen (%)	Available phosphorus (mg/kg)	Available potassium (mg/kg)
3	2.84	0.06	153.08	118.01
6	2.09	0.09	87.88	85.58
13	1.96	0.10	40.09	60.14

Table 3 Relationships among soil parameters

Soil property	Bulk density	Organic matter	Total nitrogen	Available phosphorus	Available potassium	Soil carbon stock
Bulk density	1	-	-	-	-	-
Organic matter	-.496	1	-	-	-	-
Total nitrogen	.730*	-.520	1	-	-	-
Available phosphorus	-.514	.260	-.706*	1	-	-
Available potassium	-.857**	.527	-.774*	.634	1	-
Soil carbon stock	.800**	-.536	.688*	-.513	-.967**	1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Conclusion

Results showed that soil carbon stock and some soil properties in 3, 6 and 13-year-old teak plantation had positive relationship. The soil contained high proportions of sand but with low proportions of clay. Highest carbon stocks were recorded in 13-year-old teak plantations, followed by 6 and 3-year-old teak plantations. Organic matter, available phosphorus and potassium contents were the highest in 3-year-old teak plantations, followed by 6 and 13- year-old teak plantations, respectively. Bulk density ranged between 1.2 and 1.3 g/cm^3. Total nitrogen was relatively low at 0.06-0.1%. Teak plantation in agroforestry have the potential for carbon sequestration and contribute to climate change mitigation.

Acknowledgement

Financial support for this research was provided by the Plant Genetic Conservation Project under The Royal Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn, the National Research Council of Thailand (NRTC), including Phetchaburi Rajabhat University.

References

Ajayi, O.C., Place, F., Akinnifesi, F.K. & Sileshi, G.W. (2011). Agricultural success from Africa : the case of fertilizer tree systems in southern Africa (Malawi, Tanzania, Mozambique, Zambia and Zimbabwe). *International Journal of Agricultural Sustainability*, 9 : 129 – 136.

Al Mahmud, M., Rahman, M.M., & Hossain, M.K. (2017). The effects of teak monoculture on forest soils : a case study in Bangladesh. *Journal of forestry research*, 29 : 1111-1120.

Black, C. A. (1965). *Method of soil analysis. part 2, chemical and microbiological properties.* American Society of Agronomy, Inc, Publisher, USA: Madison, Wisconsin.

Blake, G.R. & Hartge, K.H. (1996). *Bulk density, methods of soil analysis part 1 : physical and mineralogical methods*. American Society of Agronomy, Inc, Publisher, USA: Madison, Wisconsin.

Bray, R.H., & Kurtz L.T. (1945). Determination of total organic and available form of phosphorus in soil. *Soil Science,* 59 : 39-45.

Boonyanuphap, J. & Kongmeesup, I. (2016). Carbon stock of teak plantation in subtropical region of lower northern Thailand. Naresuan University Journal : Science and Technology, 24 : 64-71.

Jose, S. & Bardhan, S. (2012). Agroforestry for biomass production and carbon sequestration : an overview. *Agroforestry Systems*, 86 : 105-111.

Lorenz, K., Lal, R. (2014). Soil organic carbon sequestration in agroforestry systems. A review. *Agronomy for sustainable development*, 34, 443-454.

Omatayo, A., Ogndele, F.O., & Akoteyon, I.S. (2010). Assessment of soil properties under teak plantation in Abia-Badagry, Lagos, Nigeria. *Indonesian journal of geography*, 42 :
105 – 118.

Osujieke, D.N., Igbojionu, J.N., Imadojemu, P.E. & Iroha, J.N. (2018). Assessment of soil properties as affected by four land use types in Egbeada, South-East Nigeria. *Scientific papers series management, economic engineering in agriculture and rural development*, 18 : 309-316.

Pratt, P.E. (1965). Potassium. In Methods of Soil Analysis. *World Journal of Agricultural Research,* 2 : 12 -21.

Reddy, M.C., Priya, R.M., & Madiwalar, S.L. (2014). Carbon sequestration potential of teak plantations of different agro-climatic zones and age-gradations of southern India. *Current World Environmen*t, 9, 785-788.

Sharma, C. (2015). Physico-chemical properties of soils with special reference to organic carbon stock under different land use systems in Dimoria Tribal Belt of Assum. *Journal of agriculture and veterinary science*, 8 : 32-36.

Walkley, A. & Black, C. A. (1934). An examination of the Detjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science,* 37: 29–38.

Contact email: sudarat.cha@mail.pbru.ac.th

Assessment of Maximum Permissible Capacity of Distributed Generations Connected to a Distribution Grid with Feeder Voltage Control Equipment

Nien-Che, Yang*, National Taiwan University of Science and Technology, Taiwan
Kuan-Yu Liu, Industrial Technology Research Institute, Taiwan
Wei-Chih Tseng, Yuan Ze University, Taiwan
Hsing-Chih Chen, Industrial Technology Research Institute, Taiwan
Ting-Yen Hsieh, Industrial Technology Research Institute, Taiwan

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
The primary purpose of this study is to assess the maximum permissible capacity of distributed generations (DGs) connected to distribution systems with feeder voltage control equipment using the dual genetic algorithm (DGA), in Taiwan. The DGA is adopted to address uncertainty problems of distribution system operating states. The DGA can be subdivided into two genetic algorithm (GA) stages. In the first stage, the chromosome is used to consider the configurations of the system network of interest; those are the impedance-sensitive factors. In the second stage, the chromosome is used to consider the operating statuses of the system loads and voltage control equipment; these chromosomes are the current-sensitive factors. The existing approaches overlook the system operation conditions that may yield incorrect results and hence lead to wrong decisions in practical applications. Therefore, a maximum permissible DG capacity evaluation approach based on the DGA is proposed. The conclusions from this study are beneficial for a fast screening process for grid interconnection applications in DGs and their promotion in Taiwan.

Keywords: Distributed Generation, Voltage Control, Genetic Algorithm

iafor
The International Academic Forum
www.iafor.org

I. Introduction

With the rapid growth of distributed generations (DGs), feeder voltage control equipment have become critical in ensuring that bus voltages operate in a specific range (0.95–1.03 p.u.). Even though such equipment have been installed in distribution systems, good voltage regulation still needs to be ensured [1-5]. Some studies [6-10] have used the dual genetic algorithm (DGA) to evaluate the maximum permissible capacity of DGs. However, the voltage control equipment was not considered. It is difficult to maintain voltage level by operators in practice.

In this study, the DGA is used to determine the relationship between the maximum permissible capacity of DGs and the short-circuit capacity of the distribution system; additionally, the feeder voltage control equipment is considered. The topologies of the system networks and the operating conditions of the system loads with the voltage control equipment are evaluated in the first and second chromosomes of the GA, respectively. The simulation results can be used to accelerate grid interconnection applications in DGs by screening the capacity of DGs where the short-circuit capacity of a point of common coupling is under the lower limit from a distribution system operator's perspective.

II. Proposed Algorithm

To include most scenarios in practical distribution systems, the feasible ranges of the system parameters and the operation conditions for Taipower distribution systems are considered. In this study, the DGA is used to search the boundaries of the maximum permissible DG capacity.

2.1 DGA

The DGA can be subdivided into two GA stages. In the first stage, the topologies and parameters of the networks are regarded as impedance-sensitive control variables. In the second stage, the operating conditions of the system loads are regarded as current-sensitive control variables. The DGA is combined with the Pareto optimality to search the boundaries of the maximum permissible DG capacity.

(1) Objective function for the first GA

In the first GA stage, the topologies of the system networks are determined. The objective function for this stage is represented as (1). The constraint for the feasible ranges of the steady-state voltage deviations is defined as (2). The equality constraint for the operating power factor of the DGs is defined as (3). The inequality constraints for the feasible ranges of the operating impedance-sensitive and current-sensitive control variables are defined as (4) to (11).

$$\text{Minimize}$$

$$f_{1,i} = w_1\left(\sqrt{\sum_{j=1}^{k}(P_i(S_{MVA_j}))^2}\right)^{-1} + w_2\left(\sqrt{\sum_{j=1}^{k}(P_i(S_{MVA_j}))^2}\right) \qquad (1)$$

where w_1 and w_2 are the weighting factors, and $w_1 + w_2 = 1$. If $w_1 = 1$ and $w_2 = 0$, the objective function (1) is used to search the upper boundary of the maximum permissible DG capacity. If $w_1 = 0$ and $w_2 = 1$, the objective function (1) is used to

search the lower boundary of the maximum permissible capacity.
In (1), *i* is the *i*th chromosome, *j* is the *j*th short-circuit capacity, k is the total number of short-circuit capacities, P is the maximum permissible DG capacity, and S_{MVA} is the short capacity MVA at the interconnected point of the DGs.

$$d_i \in d_{\max} \cup \mathrm{d}_{\min} \quad (2)$$
$$\cos\theta_i = \cos\theta_{spec} \quad (3)$$
$$SSCC_{\min} \le SSCC_i \le SSCC_{\max} \quad (4)$$
$$XREI_{\min} \le XREI_i \le XREI_{\max} \quad (5)$$
$$VLP_{\min} \le VLP_i \le VLP_{\max} \quad (6)$$
$$RCST_{\min} \le RCST_i \le RCST_{\max} \quad (7)$$
$$PIST_{\min} \le PIST_i \le PIST_{\max} \quad (8)$$
$$XRST_{\min} \le XRST_i \le XRST_{\max} \quad (9)$$
$$SPFC_{\min} \le SPFC_i \le SPFC_{\max} \quad (10)$$
$$LPF_{\min} \le LPF_i \le LPF_{\max} \quad (11)$$

where d is the steady-state voltage deviation owing to DG interconnection; $\cos\theta$ is the power factor of the DGs; max is the upper boundary of the constraint; min is the lower boundary of the constraint; $spec$ is the specified value; $SSCC$ is the system short-circuit capacity at the primary side of substation transformer; $XREI$ is the X/R ratio of the system equivalent impedance; VLP is the voltage level of the primary distribution network; $RCST$ is the rated capacity of the substation transformer; $PIST$ is the percent impedance of the substation transformer; $XRST$ is the X/R ratio of the substation transformer; $SPFC$ is the size of the primary feeder conductor; LPF is the length of the primary feeder.

(2) Objective function for the second GA
In the second GA stage, the operating conditions of the system loads are determined. The objective function for this stage is represented as (12). The constraint for the feasible ranges of the steady-state voltage deviations is defined as (13). The equality constraint for the operating power factor of the DGs is defined as (14). The inequality constraints for the feasible ranges of the operating impedance-sensitive and current-sensitive control variables are defined as (15) to (21).

$$\text{Minimize} \quad f_{2,\mathrm{i}} = w_1 (P_{\mathrm{i}}(\mathrm{S}_{\mathrm{MVA_j}}))^{-1} + w_2 P_i(\mathrm{S}_{\mathrm{MVA_j}}) \quad (12)$$

where the definitions of w_1 and w_2 are the same as those defined in the preceding section.

$$d_i \in d_{\max} \cup \mathrm{d}_{\min} \quad (13)$$
$$\cos\theta_i = \cos\theta_{spec} \quad (14)$$
$$V_{\min} \le V_k \le V_{\max}, \forall k \in \{1, 2, \ldots, n\} \quad (15)$$
$$Tap_{\min} \le Tap_i \le Tap_{\max} \quad (16)$$
$$SC_{\min} \le SC_i \le SC_{\max} \quad (17)$$
$$TLPF_{\min} \le TLPF_i \le TLPF_{\max} \quad (18)$$
$$PFFL_{\min} \le PFFL_i \le PFFL_{\max} \quad (19)$$
$$DDFL_{\min} \le DDFL_i \le DDFL_{\max} \quad (20)$$

$$TLF_{\min} \le TLF_i \le TLF_{\max} \quad (21)$$

where V_k is the voltage at the *k*th bus; *n* is the total number of buses; Tap is the tap position of the on-load tap-charger (OLTC) transformer; SC is the number of shunt capacitor banks; $TLPF$ is the total load along the primary feeder; $PFFL$ is the power factor of the feeder loads; $DDFL$ is the distribution of discrete feeder loads; TLF is the total load of other feeders supplied by the same substation transformer.

(3) Optimal solution by the proposed DGA method

A flowchart of the proposed DGA method for evaluating the maximum permissible DG capacity is shown in Figure 1. The procedure of the proposed DGA method is as follows: (1) Input the feasible ranges of the system topologies and system load conditions, (2) translate the system topologies and system load conditions into the corresponding gene model, (3) set the sizes of the populations, and the probabilities of mutations and crossovers, (4) initialize the populations of the DGA, (5) implement the iteration procedure until the stopping rules are satisfied, and (6) output the optimal results obtained by the DGA.

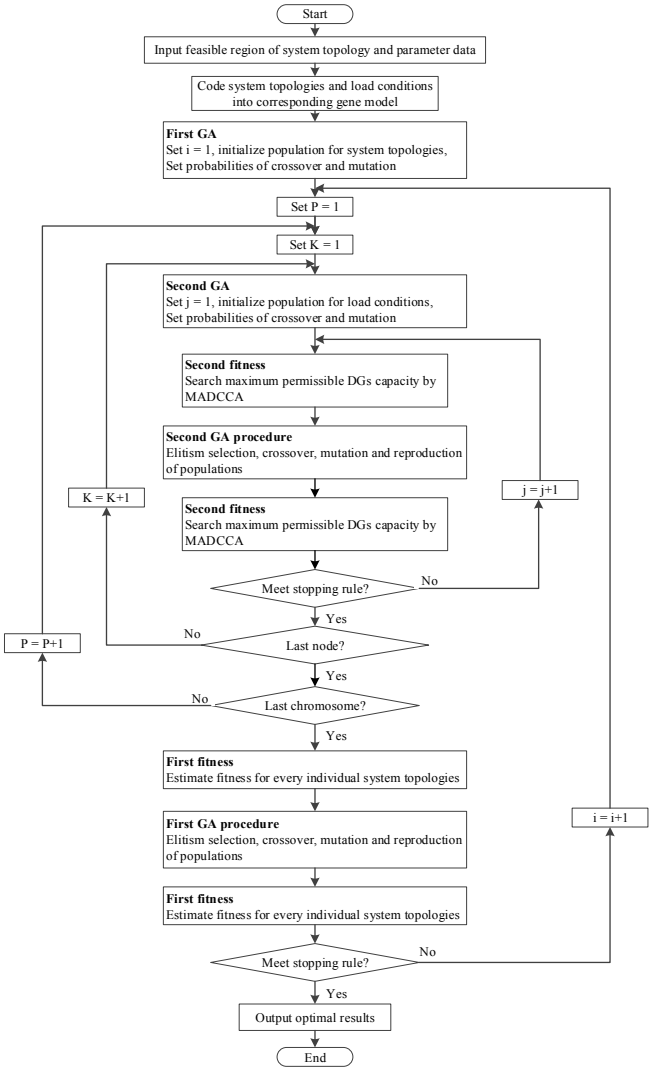


Figure 1: Flowchart of the proposed DGA method for evaluating maximum permissible DG capacity.

III Test Cases and Results

The feasible ranges for the system parameters in the Taipower distribution systems are listed in Table 1. To predetermine the range of solution sets of the maximum permissible capacity of the DGs, the operating impedance-sensitive and current-sensitive control variables for 69/11.4-, 161/11.4-, and 161/22.8-kV distribution systems (DSs) are generated randomly.

Table 1: Feasible ranges of system parameters

Factor	Feasible range for system parameters
System short-circuit capacity	800 MVA in 69/11.4-kV DSs 2,000 MVA in 161/11.4-kV DSs
Voltage level of primary feeder	11.4 kV
Rated capacity of substation transformer	12.5 MVA or 25 MVA in 69/11.4-kV DSs 30 MVA or 60 MVA in 161/11.4-kV DSs
Percent impedance of substation transformer	15%
Size of primary feeder	477 AAC with 0.131 + j0.364 Ω/km
Length of primary feeder	12 km
Peak demand at the heavy loading feeder	3 MW
Peak demand at the light loading feeder	600 kW
Total loads of other feeders	9 MW
Power factor of feeder loads	0.8 lagging
DG capacity	3 MW or 6 MW
Power factor of DG	1.0
Location of DG	Middle of feeder (6 km from substation) or end of feeder (12 km from substation)

3.1 69/11.4-kV distribution systems

(1) DG with P.F. 1.0

For 69/11.4-kV distribution systems, the case where the DGs are operated at a power factor (P.F.) of 1.0 and the steady-state voltage deviations owing to DGs are limited to 3% is shown in Figure 2. As shown, the system short-circuit capacity is proportional to the maximum permissible DG capacity. That is, the larger the system short-circuit capacity, the higher are the maximum DG capacities allowed. Generally, the maximum permissible capacities of the DGs are restricted by the limitations of steady-state voltage deviation owing to the DGs and the maximum continuous operation currents of the feeders and transformers. If the system short-circuit capacity is larger than 60 MVA, the maximum permissible capacity of the DGs is restricted by the maximum thermal limitation of the feeders (6 MVA).

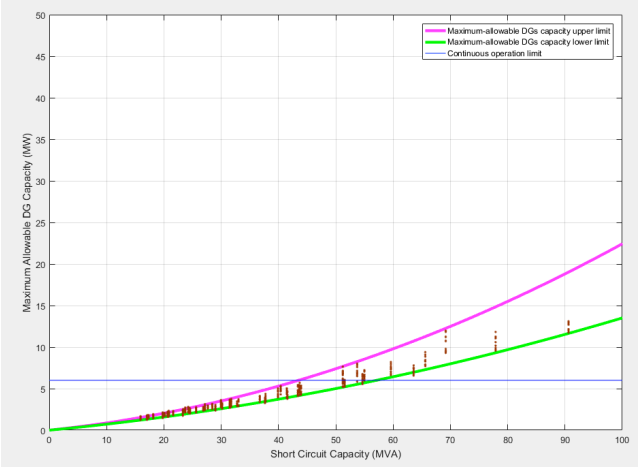


Figure 2: Maximum permissible DG capacity versus short-circuit capacity at the connection point of DG for 69/11.4-kV distribution systems (DG P.F. = 1.0 and d% = 3%)

(2) DG with P.F. 0.9 lagging

For 69/11.4-kV distribution systems, the case where the DGs are operated at a P.F. of 0.9 lagging and the steady-state voltage deviations owing to DGs are limited to 3% is shown in Figure 3. If the DGs are operated at P.F. lagging, the reactive power is produced by the DGs. Therefore, the voltage drops along the feeder are improved. The voltage magnitudes at the nodes along the considered feeder are increased proportionally. That is, the steady-state voltage deviations owing to the DGs are greater than the specified steady-state voltage deviation limitation. With the same system short-circuit capacity, the maximum permissible capacity of the DGs with a P.F. of 0.9 lagging is less than that of 1.0.

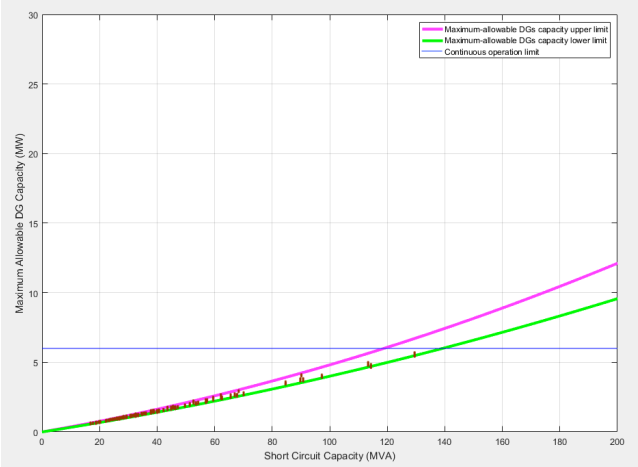


Figure 3: Maximum permissible DG capacity versus short-circuit capacity at the connection point of DG for 69/11.4-kV distribution systems (DG P.F. = 0.9 lagging and d% = 3%)

(3) DG with P.F. 0.9 leading

For 69/11.4-kV distribution systems, the case where the DGs are operated at a P.F. of 0.9 leading and the steady-state voltage deviations owing to DGs are limited to 3% is shown in Figure 4. As shown, the maximum permissible capacity of the DGs with a P.F. of 0.9 leading is larger than that of 1.0. If the system short-circuit capacity is

larger than 55 MVA, the maximum permissible capacity of the DGs is restricted by the maximum thermal limitation of the feeders (6 MVA). Therefore, the operating power factor of the DGs exhibit significant effects on the steady-state voltage deviations along the feeders.

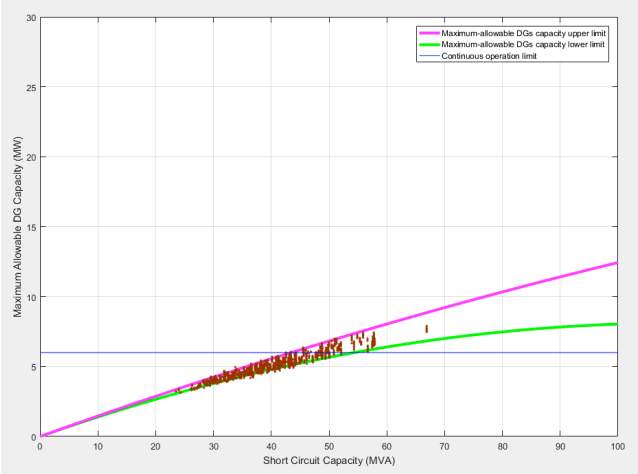


Figure 4: Maximum permissible DG capacity versus short-circuit capacity at the connection point of DG for 69/11.4-kV distribution systems (DG P.F. = 0.9 leading and d% = 3%)

3.2 161/11.4-kV distribution systems

(1) DG with P.F. 1.0

For 161/11.4-kV distribution systems, the case where the DGs are operated at a P.F. of 1.0 and the steady-state voltage deviations owing to DGs are limited to 3% is shown in Figure 5. If the system short-circuit capacity is larger than 65 MVA, the maximum permissible capacity of the DGs is restricted by the maximum thermal limitation of the feeders (6 MVA).

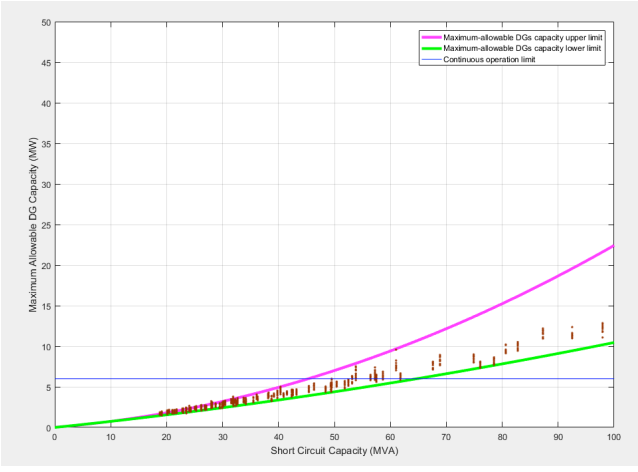


Figure 5: Maximum permissible DGs capacity versus short-circuit capacity at the connection point of DG for 161/11.4-kV distribution systems (DG P.F. = 1.0 and d% = 3%)

(2) DG with P.F. 0.9 lagging

For 161/11.4-kV distribution systems, the case where the DGs are operated at a P.F. of 0.9 lagging and the steady-state voltage deviations owing to DGs are limited to 3%

is shown in Figure 6. If the system short-circuit capacity is larger than 150 MVA, the maximum permissible capacity of the DGs is restricted by the maximum thermal limitation of the feeders (6 MVA).

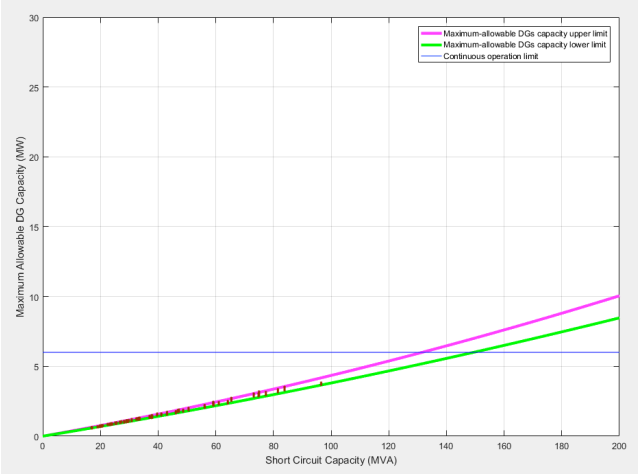


Figure 6: Maximum permissible DGs capacity versus short-circuit capacity at the connection point of DG for 161/11.4-kV distribution systems (DG P.F. = 0.9 lagging and d% = 3%)

(3) DG with P.F. 0.9 leading

For 161/11.4-kV distribution systems, the case where the DGs are operated at a P.F. of 0.9 leading and the steady-state voltage deviations owing to DGs are limited to 3% is shown in Figure 7. If the system short-circuit capacity is larger than 55 MVA, the maximum permissible capacity of the DGs is restricted by the maximum thermal limitation of the feeders (6 MVA).

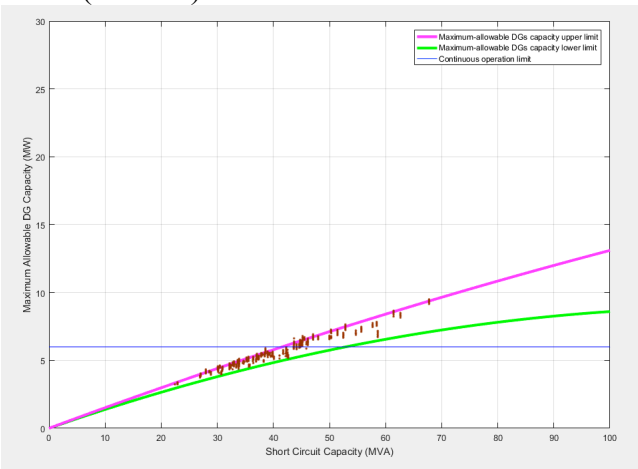


Figure 7: Maximum permissible DGs capacity versus short-circuit capacity at the connection point of DG for 161/11.4-kV distribution systems (DG P.F. = 0.9 leading and d% = 3%)

3.3 161/22.8 kV distribution systems

(1) DG with P.F. 1.0

For 161/22.8-kV distribution systems, the case where the DGs are operated at a P.F. of 1.0 and the steady-state voltage deviations owing to DGs are limited to 3% is shown in Figure 8. If the system short-circuit capacity is larger than 230 MVA, the maximum permissible capacity of the DGs is restricted by the maximum thermal

limitation of the feeders (12 MVA).

(2) DG with P.F. 0.9 lagging

For 161/22.8-kV distribution systems, the case where the DGs are operated at a P.F. of 0.9 lagging and the steady-state voltage deviations owing to DGs are limited to 3% is shown in Figure 9.

(3) DG with P.F. 0.9 leading

For 161/22.8-kV distribution systems, the case where the DGs are operated at a P.F. of 0.9 leading and the steady-state voltage deviations owing to DGs are limited to 3% is shown in Figure 10. If the system short-circuit capacity is larger than 100 MVA, the maximum permissible capacity of the DGs is restricted by the maximum thermal limitation of the feeders (12 MVA).

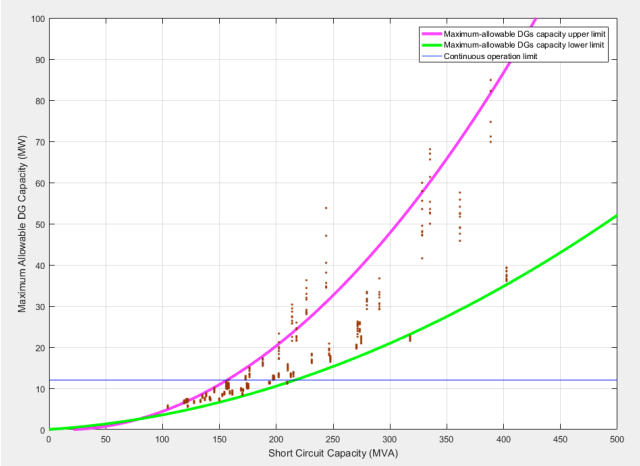


Figure 8: Maximum permissible DGs capacity versus short-circuit capacity at the connection point of DG for 161/22.8-kV distribution systems (DG P.F. = 1.0 and d% = 3%)

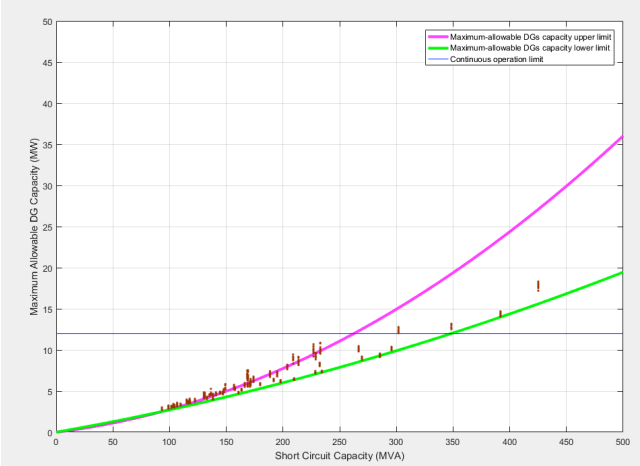


Figure 9: Maximum permissible DGs capacity versus short-circuit capacity at the connection point of DG for 161/22.8-kV distribution systems (DG P.F. = 0.9 lagging and d% = 3%)

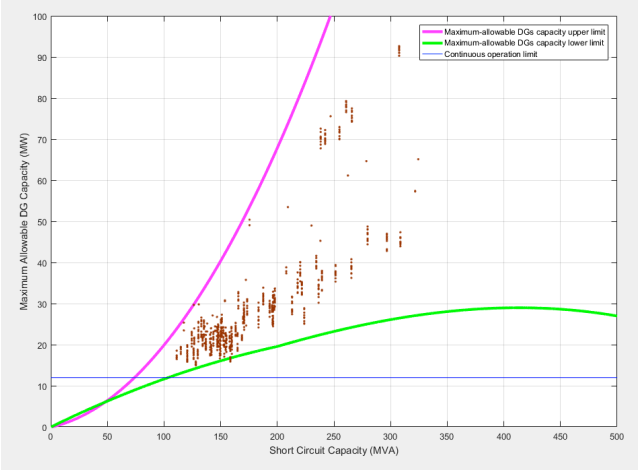


Figure 10: Maximum permissible DGs capacity versus short-circuit capacity at the connection point of DG for 161/22.8-kV distribution systems (DG P.F. = 0.9 leading and d% = 3%)

IV Conclusion

In this study, various system-planning-based factors affecting the maximum permissible DG capacity were investigated. The primary factors that affected the maximum permissible DG capacity were (1) the system short-circuit capacity at the primary side of the substation transformer, (2) the X/R ratio of the system equivalent impedance, (3) the voltage level of the primary distribution network, (4) the rated capacity of the substation transformer, (5) the percent impedance of the substation transformer, (6) the X/R ratio of the substation transformer, (7) the size of the primary feeder conductor, (8) the length of the primary feeder, (9) the tap position of the OLTC transformer, (10) the number of capacitor banks, (11) the total load along the primary feeder, (12) the power factor of the feeder loads, (13) the distribution of discrete feeder loads, (14) the total loads of other feeders supplied by the same substation transformer, (15) the power factor of the DGs. The results of this study indicated that the operating power factors of the loads and DGs majorly affected the maximum permissible DG capacity, among the primary factors listed above. Hence, the application of voltage and reactive power compensation techniques may be effective for increasing the maximum permissible capacity of DGs.

Acknowledgments

This work was financially supported by the Bureau of Energy, Ministry of Economic Affairs under the project of Shalun Green Energy Science City – Project of Verification Platform for Industrial Green Technology. (Project number: 108-D0603)

References

[1] M. Z. Kamh and R. Iravani. (2010). Unbalanced model and power-flow analysis of microgrids and active distribution systems. *IEEE Transactions on Power Delivery,* 25, 2851-2858.

[2] N.-C. Yang and H.-C. Chen. (2018). Decomposed Newton algorithm-based three-phase power-flow for unbalanced radial distribution networks with distributed energy resources and electric vehicle demands. *International Journal of Electrical Power & Energy Systems,* 96, 473-483.

[3] N.-C. Yang and W.-C. Tseng. (2015). Adaptive three-phase power-flow solutions for smart grids with plug-in hybrid electric vehicles. *International Journal of Electrical Power & Energy Systems,* 64, 1166-1175.

[4] T.-H. Chen, L.-S. Chiang, and N.-C. Yang. (2012). Examination of Major Factors Affecting Voltage Variation on Distribution Feeders. *Energy and Buildings,* 55, 494-499.

[5] W. K. Wong, D. L. Osborn, and J. L. McAvoy. (1990). Application of Compact Static VAR Compensators to Distribution Systems. *IEEE Transactions on Power Delivery,* 5, 1113-1120.

[6] N.-C. Yang and T.-H. Chen. (2011). Evaluation of Maximum Allowable Capacity of Distributed Generations Connected to a Distribution Grid by Dual Genetic Algorithm. *Energy and Buildings,* 43, 3044-3052.

[7] N. C. Yang and T. H. Chen. (2011). Dual Genetic Algorithm-Based Approach to Fast Screening Process for Distributed-Generation Interconnections. *IEEE Transactions on Power Delivery,* 26, 850-858.

[8] D. M, G. GP, M. P, and M. M. (2000). Optimal capacitor placement using deterministic and genetic algorithms. *IEEE Transactions on Power Systems,* 15, 1041-1046.

[9] A. E.-E. AA, A. SM, and S. M. E. P. S. Res. (2010). Maximal optimal benefits of distributed generation using genetic algorithms. *Electrical Power Systen Resouce,* 80, 869-877.

[10] H. H, N. SA, and A. A. (2008). A method for placement of DG units in distribution networks. *IEEE Transactions on Power Delivery,* 23, 1620-1628.

Contact email: ncyang@mail.ntust.edu.tw

Cost and Benefit Optimization on Installation of Distribution Feeders Voltage Control Equipment considering Distributed Generations

Nien-Che, Yang*, National Taiwan University of Science and Technology, Taiwan
Kuan-Yu Liu, Industrial Technology Research Institute, Taiwan
Wei-Chih Tseng, Yuan Ze University, Taiwan
Hsing-Chih Chen, Industrial Technology Research Institute, Taiwan
Ting-Yen Hsieh, Industrial Technology Research Institute, Taiwan

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
The primary purpose of this study is to explore the impacts of distributed generation (DG) interconnections on distribution systems in Taiwan. To build a DG-friendly distribution system for the development of DGs, a genetic algorithm with Pareto optimality is utilized to analyze the cost and benefit of installing a distribution feeder voltage control equipment that considers DGs. The major objectives include minimizing the total cost of installing the distribution feeder voltage control equipment and maximizing DG utilization. The total cost includes the installation cost and operation cost of the voltage control equipment. The results indicate that the voltage control equipment is important for improving the voltage profile along the feeders, reducing the system power losses, and maximizing the possible installed capacity of DGs. The conclusions from this study are crucial to DG interconnections and for promoting the future development of renewable energy in Taiwan.

Keywords: Distributed Generation, Voltage Control, Genetic Algorithm.

iafor
The International Academic Forum
www.iafor.org

I. Introduction

According to the governmental policy in Taiwan, hybrid power generation of renewable energy will increase from the present 4.6% to 20% by 2025. When the amount of renewable energy power generation increases significantly, the power quality and the stability of power grid operations are affected. To explore the impacts of distributed generation (DG) interconnections on distribution systems in Taiwan, the voltage deviations of all system buses in the distribution systems are evaluated. The standard of voltage deviation is 0.95–1.03 p.u., according to the Taipower interconnection grid codes. The benefits of installing distribution feeder voltage control equipment and the techniques of reactive power device control (RPDC) used in Taipower were evaluated.

In previous studies [1-4], the voltage deviations of all buses could not satisfy the requirements of grid codes under some scenarios. That is, the voltage control equipment installed at the substation could regulate the voltages at the secondary side of the substation transformer. Because of this drawback of RPDC, an automatic voltage regulator (AVR) is an economical solution to improve voltage deviations along feeders. In this study, an automatic voltage regulator is utilized to improve the voltage profile along feeders. System index factors such as voltage deviations, operation sequences of RPDC, and maximum permissible capacity of DGs are calculated after performing power flow solutions.

II. Proposed Algorithm

The maximum permissible capacity of DGs is restricted by the limitations of steady-state voltage deviations caused by the DG interconnection and maximum continuous operating current of the feeder [5-9]. To reduce this steady-state voltage deviation, utilizing a feeder voltage control equipment is a reasonable solution to maintain the node voltages along a distribution feeder within a permissible range. Hence, the impact assessment for DG interconnections, and cost and benefit optimizations for the sizing and siting of voltage control equipment are proposed in this paper.

2.1 Impact assessment for DG interconnection

To evaluate the impact of DGs on distribution systems, the Monte-Carlo-based power flow method is used in this study. In the feasible regions of interest of the distribution systems, the possible combinations of system topologies and load states, such as (1) system short-circuit capacity, (2) rated capacity of the main transformer, (3) percent impedance of the main transformer, (4) size of the feeder primary conductor, (5) length of the primary feeder, (6) discrete loads along the feeder, (7) power factors of feeder loads, and (8) distribution of feeder loads, are generated. The flowchart of the impact assessment for the DG interconnections is shown in Fig. 1. The calculation procedure is described as follows: (1) set voltage level, (2) set steady-state voltage deviation limitations, (3) set initial system topologies, (4) set feasible region of system parameter data, (5) set number of simulations, (6) initialize system parameters randomly, (7) search the maximum permissible DG capacity by the maximum allowable DG capacity calculation algorithm (MADCCA), (8) regulate feeder voltages by RPDC, and (9) output the results.

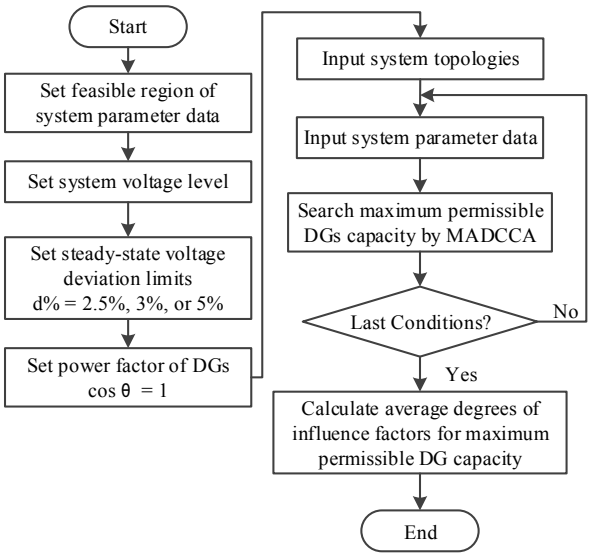


Figure 1: Flowchart of impact assessment for DG interconnection.

The MADCCA is necessary for the calculation procedure described as follows: (1) initial estimate of the maximum permissible DG capacity, (2) power flow calculation, (3) estimation of voltage deviation, and (4) modification of the maximum permissible DG capacity for the next trail value. The flowchart for the MADCCA is shown in Fig. 2.

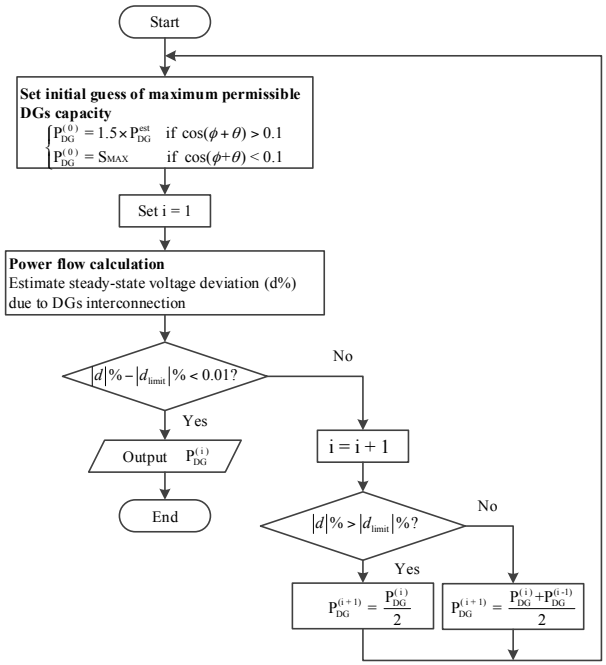


Figure 2: Flowchart for maximum permissible DG capacity calculation algorithm.

2.2 Genetic Algorithm

To optimize the sizing and siting of the voltage control equipment, a genetic algorithm (GA)-based method with a Pareto front is developed. For the proposed method, the sizing and siting of AVRs are the control variables. The first objective is to establish a cost function for searching the minimum cost after installing the AVRs. The second objective is to establish a benefit function for searching the maximum increase in the maximum permissible DG capacity after installing the AVRs. The

flowchart of the proposed GA-based method with a Pareto front is shown in Fig. 3. The solution procedure is described as follows: (1) input the feasible region of system parameters and iteration constraints, (2) initialize the coefficients for the proposed algorithm, (3) set the probabilities of crossover and mutation, (4) estimate the fitness for every individual within the populations, (5) perform elitism, crossover, and mutation between individuals, and reproduce the next-generation populations (6) re-estimate the fitness for every individual within the populations, and (7) verify the stopping rules.

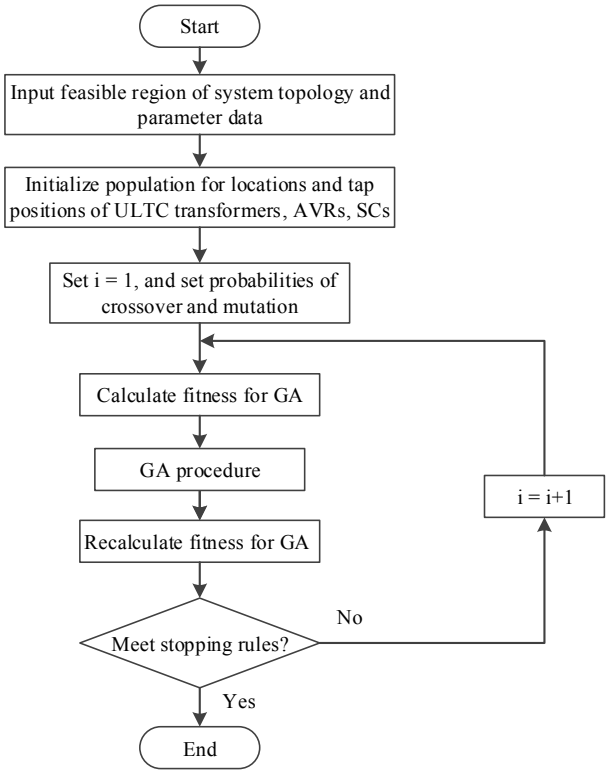


Figure 3: Flowchart of GA-based method with Pareto front for sizing and siting of voltage control equipment.

2.3 Pareto Optimality

Generally, optimization problems can be divided into single- and multiobjective problems. In single-objective optimization problems, an objective function is used for searching a single optimization solution. In multiobjective optimization problems, various objective functions are minimized simultaneously; however, some objectives may conflict with one another, and no single solution can minimize all objectives simultaneously. Hence, a set of nondominated solutions, called Pareto optimal solutions, is used to find good solutions to multiobjective problems as shown in Fig. 4. Pareto optimality can be described mathematically as follows:

$$\forall i \in \{1,2,...,n_f\}, \quad f_i(\vec{x}_1) \le f_i(\vec{x}_2) \qquad (1)$$

$$\exists j \in \{1,2,...,n_f\}, \quad f_j(\vec{x}_1) < f_j(\vec{x}_2) \qquad (2)$$

If both the abovementioned conditions are satisfied, the solution $\vec{x}_1$ dominates solution $\vec{x}_2$.

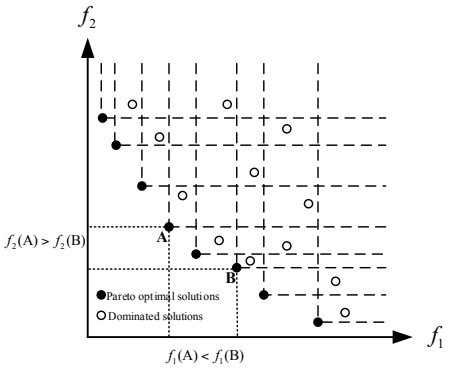


Figure 4: Pareto front for a two-objective problem.

To simulate the impact of DG interconnection on distribution systems, a sample system is used, as shown schematically in Fig. 5. The parameters for the AVR, on-load tap charger (OLTC) transformer, and shunt capacitor (SC) are shown in Tables 1 and 2. The feasible ranges of system parameters for 11.4- and 22.8-kV distribution systems are shown in Tables 3 and 4, respectively. To consider the time-to-time, day-to-day, and season-to-season changes in the load demands and power generations, eight daily characteristic curves are used to represent the power consumption and power generation behaviors for each type of load demand, photovoltaic (PV) generation, and wind generation.

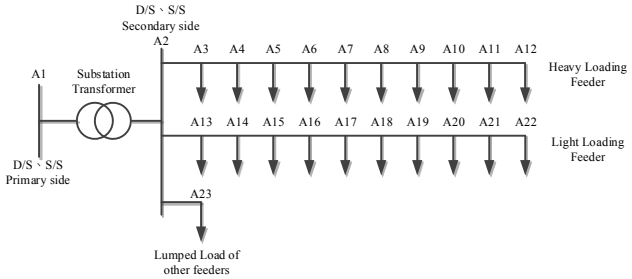


Figure 5: Schematic diagram of the sample system.

Table 1: Parameters for AVR.

Equipment	Parameters
AVR	1. Number of taps: 32 (±16); 2. Controllable voltage for each tap: 0.00625 p.u.; 3. Range of controllable voltage: ±10%

Table 2: Parameters for OLTC transformer and SC.

Equipment	Parameters
OLTC	1. Number of taps: 32 (±16); 2. Controllable voltage for each tap: 0.00625 p.u.; 3. Range of controllable voltage: ±10%
SC	1. Number of capacitor banks: 2 2. Rated capacity of each capacitor bank: 3 Mvar 3. Total rated capacity of capacitor banks: 6 Mvar

Table 3: Feasible ranges of system parameters for 11.4-kV distribution systems

Factor	Parameters
System short-circuit capacity	800 MVA in 69/11.4 kV DSs 2,000 MVA in 161/11.4 kV DSs
X/R ratio of equivalent system impedance	6.0–6.5
Rated capacity of substation transformer	12.5 MVA or 25 MVA in 69/11.4 kV DSs 30 MVA or 60 MVA in 161/11.4 kV DSs
Percent impedance of substation transformer	5–15%
X/R ratio of substation transformer	10–20
Size of primary feeder	477AAC: 0.131 + j0.364 Ω/km
Length of primary feeder	5–12 km
Total loads of a given feeder	600 kW–3 MW
Total loads of other feeders	2–9 MW
Power factor of feeder loads	0.8 lagging–1.0

Table 4: Feasible ranges of system parameters for 22.8-kV distribution systems

Factor	Parameters
System short-circuit capacity	2,000–8,000 MVA
X/R ratio of equivalent system impedance	6.0–6.5
Rated capacity of substation transformer	30 MVA or 60 MVA
Percent impedance of substation transformer	5–15%
X/R ratio of substation transformer	10–20
Size of primary feeder	500 MCM: 0.1469 + j0.1325 Ω/km
Length of primary feeder	5–20 km
Total loads of a given feeder	1.2–6 MW
Total loads of other feeders	4.8–24 MW
Power factor of feeder loads	0.8 lagging–1

2.4 Objective Functions

To ensure voltage quality along feeders and minimize the investment of installing the AVRs, the cost and benefit functions for installing the AVRs are adopted in this study.

(a) Cost function:

Minimize

$$\begin{aligned} f_1 = & \sum_{p=1}^{12}\sum_{l=1}^{n}\sum_{k=1}^{m}\sum_{j=1}^{24}\alpha_1\sum_{i=1}^{N_{AVR}}J_{AVR,i} \\ & +\sum_{p=1}^{12}\sum_{l=1}^{n}\sum_{k=1}^{m}\sum_{j=1}^{24}\alpha_2 C_{main,tap}\left|Tap_{main,after,j}^{k,l,p}-Tap_{main,before,j}^{k,l,p}\right| \\ & +\sum_{p=1}^{12}\sum_{l=1}^{n}\sum_{k=1}^{m}\sum_{j=1}^{24}\alpha_3 C_{cap}\left|N_{Cap,after,j}^{k,l,p}-N_{Cap,before,j}^{k,l,p}\right| \\ & +\sum_{p=1}^{12}\sum_{l=1}^{n}\sum_{k=1}^{m}\sum_{j=1}^{24}\alpha_4 C_{AVR,tap}\left|Tap_{AVR,after,j}^{k,l,p}-Tap_{AVR,before,j}^{k,l,p}\right| \end{aligned} \quad (3)$$

where $J_{AVR,i}$ is the investment cost of the ith AVR ($); N_{AVR} is the number of AVR; $C_{main,tap}$ is the operating cost of the OLTC transformer ($/p.u.); C_{cap} is the operating cost of the shunt capacitor ($/p.u.); $C_{AVR,tap}$ is the operating cost of the AVR ($/p.u.); $Tap_{main,before,j}^{k,l,p}$, $N_{Cap,before,j}^{k,l,p}$, and $Tap_{AVR,before,j}^{k,l,p}$ are the tap positions of the OLTC transformer, number of shunt capacitors, and tap position of the AVR at the *j*th hour, *l*th day, *p*th month under the *k*th loading condition before installing AVR, respectively; $Tap_{main,after,j}^{k,l,p}$, $N_{Cap,after,j}^{k,l,p}$, and $Tap_{AVR,after,j}^{k,l,p}$ are the tap position of the OLTC transformer, number of shunt capacitors, and tap position of the AVRs at the *j*th hour, *l*th day, *p*th month under the *k*th loading condition after installing the AVRs, respectively; α_1, α_2, α_3, and α_4 are cost weighting coefficients. Here, α_1=300 (*p.u./$*), α_2=3 (*p.u./$*), α_3=5 (*p.u./$*), and α_4=1 (*p.u./$*)。

(b) Benefit function:

Minimize

$$f_2 = \sum_{p=1}^{12}\sum_{l=1}^{n}\sum_{k=1}^{m}\sum_{j=1}^{24}\beta\cdot(P_{DG,before,j}^{k,l,p}-P_{DG,after,j}^{k,l,p}) \quad (4)$$

$$P_{DG,j} = \gamma_1 P_{PV,j} + \gamma_2 P_{wind,j} \quad (5)$$

where $P_{DG,after,i}^{k,l,p}$ is the permissible capacity of the DGs (MW) at the *j*th hour, *l*th day, *p*th month under the *k*th loading condition after installing the AVRs; $P_{DG,before,i}^{k,l,p}$ is the permissible capacity of the DGs (MW) at the *j*th hour, *l*th day, *p*th month under the *k*th loading condition before installing the AVRs; β is the benefit coefficient for the DGs. Herein, β = 60(*p.u./MW*). $P_{PV,i}$ is the real power generation (MW) of the PV system at the *j*th hour; $P_{wind,i}$ is the real power generation (MW) of the wind power system at the *j*th hour; γ_1 is the ratio of PV power generation to DG power generation, and γ_2 is the ratio of wind power generation to DG power generation.

III. Simulation Results

The simulation results of the cost and benefit optimization for 69/11.4- and 161/11.4-kV distribution systems with DGs are shown in Tables 5 and 6, respectively. Figs. 6 to 11 show the Pareto front obtained using the proposed method for six

scenarios. In most cases, the optimal locations of DGs are along the light loading feeder. In this case, the wide voltage spread between the light loading feeder and heavy loading feeder can be reduced, and the permissible capacity of the DGs can be increased.

Table 5: Multiobjective optimization for sizing and siting of AVRs in 69/11.4-kV distribution systems with DGs

Scenarios	Objective function	Location of AVRs		f_1	f_2
		Feeder	Distance from the transformer (m)	Cost (p.u.)	Benefit (p.u.)
6 MW of DGs at the end of light loading feeder	Minimum cost	Light loading	7,994–8,221	2625	–494,898
	Maximum benefit	Light loading	7,206–7,233	573.75	–561,503
3 MW of DGs at the end of light loading feeder	Minimum cost	Light loading	2,422–3,452	–1616.25	–79,590
	Maximum benefit	Light loading	144–2,321	–1342.5	–86,221
6 MW of DGs at the middle end of light loading feeder	Minimum cost	Light loading	5,388–5,396	–1205.625	–367,697
	Maximum benefit	Light loading	3,921–4,785	–658.125	–532,454

Table 6: Multiobjective optimization for sizing and siting of AVRs in 161/11.4 kV-distribution systems with DGs

Scenarios	Objective function	Location of AVRs		f_1	f_2
		Feeder	Distance from the transformer (m)	Cost (p.u.)	Benefit (p.u.)
6 MW of DGs at the end of light loading feeder	Minimum cost	Light loading	8,304–8,312	163.125	–492,656
	Maximum benefit	Light loading	26–81	5,501.25	–569,163
3 MW of DGs at the end of light loading feeder	Minimum cost	Light loading	2,694–7,152	–247.5	–69,691
	Maximum benefit	Light loading	300–2,312	26.25	–95,699
6 MW of DGs at the middle end of light loading feeder	Minimum cost	Light loading	5701	300	–378,496
	Maximum benefit	Light loading	2,415–3,519	847.5	–581,507

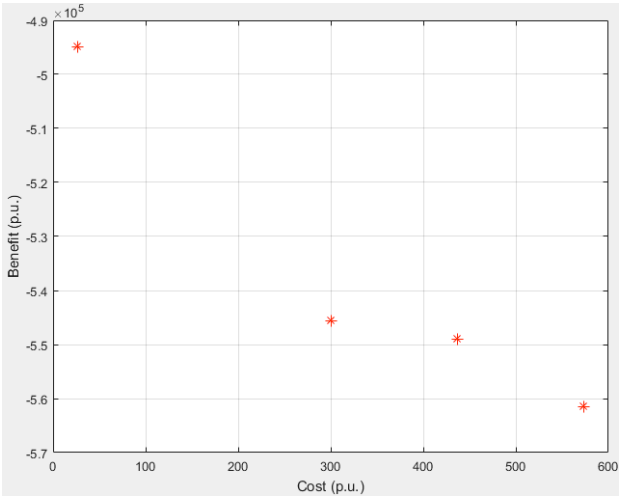


Figure 6: Pareto front for 3 MW of DGs interconnected at the end of light loading feeder (69/11.4-kV distribution systems)

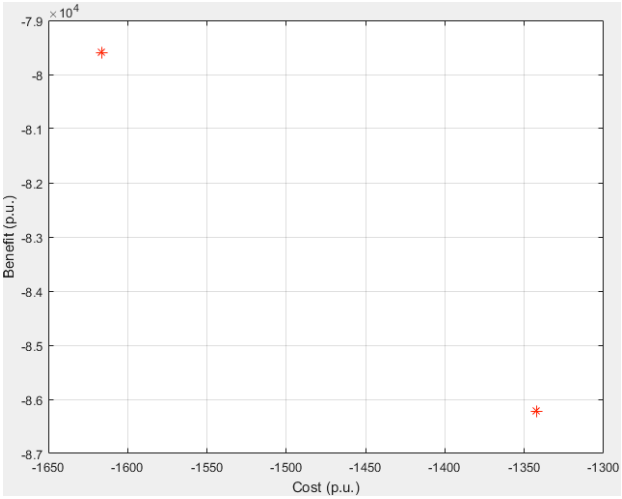


Figure 7: Pareto front for 6 MW of DGs interconnected at the end of light loading feeder (69/11.4-kV distribution systems)

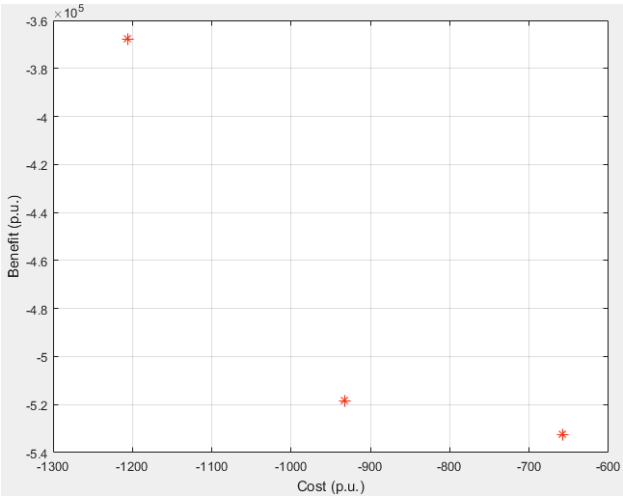


Figure 8: Pareto front for 6 MW of DGs interconnected at the middle of light loading feeder (69/11.4-kV distribution systems)

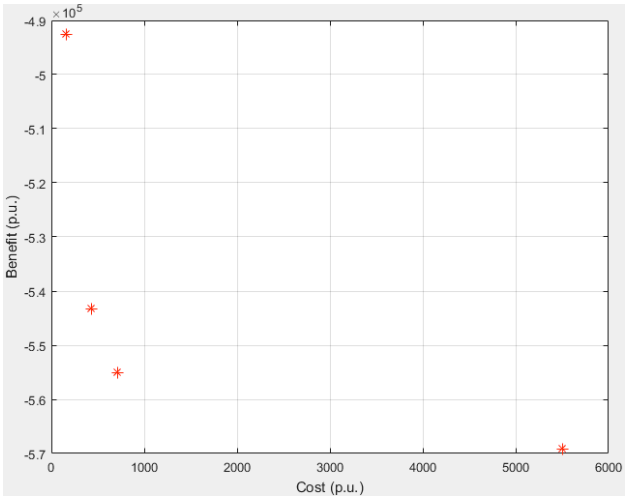


Figure 9: Pareto front for 3 MW of DGs interconnected at the end of light loading feeder (161/11.4-kV distribution systems)

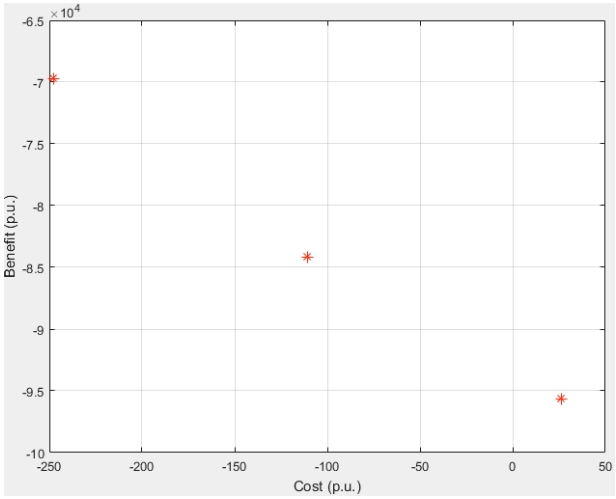


Figure 10: Pareto front for 6 MW of DGs interconnected at the end of light loading feeder (161/11.4-kV distribution systems)

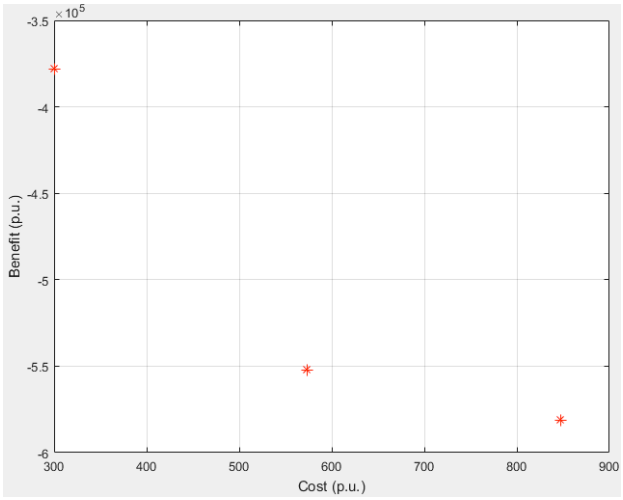


Figure 11: Pareto front for 6 MW of DGs interconnected at the middle of light loading feeder (161/11.4-kV distribution systems)

IV. Conclusion

In this study, the GA based method with Pareto optimality was developed to optimize the cost and benefit of installing an AVR in distribution feeders with DGs. First, the impacts of DG interconnections on distribution systems in Taiwan were investigated. The worst cases were used as sample systems. The primary objectives included minimizing the total cost of installing distribution feeder voltage equipment and maximizing the DGs utilization. The total cost included the installation cost and operation cost of the voltage control equipment. The conclusions from this study are crucial to the DG interconnections and for promoting the future development of renewable energy in Taiwan.

Acknowledgements

This work was financially supported by the Bureau of Energy, Ministry of Economic Affairs under the project of Shalun Green Energy Science City – Project of Verification Platform for Industrial Green Technology. (Project number: 108-D0603)

References

[1] N.-C. Yang and H.-C. Chen. (2018). Decomposed Newton algorithm-based three-phase power-flow for unbalanced radial distribution networks with distributed energy resources and electric vehicle demands. *International Journal of Electrical Power & Energy Systems,* 96, 473-483.

[2] N.-C. Yang and H.-C. Chen. (2017). Three-phase power-flow solutions using decomposed quasi-Newton method for unbalanced radial distribution networks. *IET Generation, Transmission & Distribution,* 11, 3594-3600.

[3] N.-C. Yang. (2016). Three-phase power flow calculations using direct Z BUS method for large-scale unbalanced distribution networks. *IET Generation, Transmission & Distribution,* 10, 1048-1055.

[4] T.-H. Chen, L.-S. Chiang, and N.-C. Yang. (2012). Examination of Major Factors Affecting Voltage Variation on Distribution Feeders. *Energy and Buildings,* 55, 494-499.

[5] G. S, G. SP, and G. S. (2010). Optimal sizing and placement of distributed generation in a network system. *International Journal Electrical Power Energy System,* 32, 849-856.

[6] H. H, N. SA, and A. A. (2008). A method for placement of DG units in distribution networks. *IEEE Transactions on Power Delivery,* 23, 1620-1628.

[7] W. CS and N. MH. (2004). Analytical approaches for optimal placement of distributed generation sources in power systems. *IEEE Transactions on Power Systems,* 19, 2068-2076.

[8] N.-C. Yang and T.-H. Chen. (2011). Evaluation of Maximum Allowable Capacity of Distributed Generations Connected to a Distribution Grid by Dual Genetic Algorithm. *Energy and Buildings,* 43, 3044-3052.

[9] N. C. Yang and T. H. Chen. (2011). Dual Genetic Algorithm-Based Approach to Fast Screening Process for Distributed-Generation Interconnections. *IEEE Transactions on Power Delivery,* 26, 850-858.

Contact email: ncyang@mail.ntust.edu.tw

Climate-Based Daylight Metrics Applied for Sustainable and High-Quality Design Strategy of Office Spaces

Yu-Chan Chao, Feng Chia University, Taiwan
Yu-Yun Huang, Feng Chia University, Taiwan

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
Daylight using in office space not only has the energy-saving potential, but also achieve visual requirements and improve work efficiency. In the past, "Daylight factor (DF)" has always been the mainstream of building daylight specifications. However, "static" Daylight factor cannot fully reflect the change of time, nor the relationship between building orientation and external shading. In recent years, "Dynamic Daylight Metrics" based on meteorological data has become a new evaluation trend, which can accurately evaluate the daylight quality in the annual working hours of the building. To evaluate the daylight condition of Taiwan's office space, this study used the " Typical Meteorological Year (TMY3)" as the database of climate, and applied the dynamic lighting index "Spatial Daylight Autonomy (sDA)" and "Annual solar Exposure value (ASE)" as the dynamic daylight evaluation index, which are commonly used internationally. Through simulation with DIVA for Rhino software, daylight design strategies such as window-to-wall ratio, window types, shading for office space were discussed to achieve the purpose of sustainable building design and high-quality daylight environment.

Keywords: Dynamic Daylight Metrics, Spatial Daylight Autonomy, Annual solar Exposure value, Daylight Design, TMY3

iafor
The International Academic Forum
www.iafor.org

Introduction

According to statistics, lighting energy consumption of buildings accounts for about 25% of the total energy consumption. If natural light is fully used, it can not only save a lot of daytime lighting energy, but also effectively enhance work efficiency (Vine et al., 1998). In particular, Taiwan is in a low latitude area with long sunshine hours and excellent natural lighting design potential.

In recent years, European and American countries have promoted “Dynamic Daylight Metrics”, which can complete the local climate data, spatial geometry and material reflectance, and make the indoor space lighting assessment closer to the actual situation. . For example, the US Green Building Council (USGBC) Green Building Evaluation Index LEED V4 specifically mentions (USGBC, 2013): To enhance the link between building users and nature, to enhance the physiological regularity of people staying up late, while introducing natural light to reduce lighting energy consumption, Dynamic lighting design is an indispensable design project.

This study takes Taiwan's common office space as the research object and takes Taichung City as the research site. Typical Meteorological Year 3 (TMY3) is used as the climate data, and the "Spatial Daylight Autonomy (sDA) " and "Annual Sun Exposure (ASE)" are used as dynamic daylight metrics. This study uses DIVA for Rhino software to simulate and verify daylight distribution, and evaluates the appropriate window type, lighting depth and shading design method for office space, in order to achieve the purpose of green building energy-saving design and high-quality lighting environment.

Theory and Method

1. Dynamic daylight metrics

(1) Spatial Daylight Autonomy, sDA
Spatial Daylight Autonomy (sDA) describes how much of a space receives sufficient daylight. Specifically, it describes the percentage of floor area that receives at least 300 lux for at least 50% of the annual occupiable hours, which is the standard recommended by IES. The occupiable hours are usually set from 8:00 to 18:00, in total of 10 hours. This indicator helps find a space suitable for using sDA for a long-term period. If the sDA exceeds 75%, the daylight is considered to be excellent; 74% to 55% means acceptable daylight, and if less than 55%, the daylight is considered to be poor.

(2) Annual Sunlight Exposure, ASE
Although sDA encourages a high proportion of spatial daylight, the increase in spatial daylight also greatly increases the potential of glare and solar thermal energy. Therefore, the ASE indicator is designed to limit the excessive amount of sunlight in space. The base value for ASE is ASE1000, 250, which means ASE measures the percentage of floor area that receives at least 1000 lux for at least 250 occupied hours per year. IES also points out that if the ASE in the space is higher than 10%, it means that it may be too bright, causing visual discomfort.

2. Simulation software for dynamic daylight

DIVA for Rhino is a highly optimized daylighting and energy modeling plug-in application with the functions of radiation Map, real rendering, climate-based daylight indicators, and glare analysis at annual and specific time points. This plug-in application reviews the compliance with LEED metrics and calculation of energy and load in a single thermal comfort zone. In view of the high precision and better operating interface of DIVA for Rhino and its support of the calculation and review of dynamic daylight indicators, this study will use DIVA for Rhino as the simulation software for office space dynamic daylight, and examine and analyze each result of the dynamic daylight in the aforementioned setting of office space and facade window. The operation settings are shown as below:

A. Build a model: Use Rhinoceros to build a spatial model and then divide it into different layers according to the building components such as ceilings, walls or windows.

B. Set the base location: Import the data from TMY3 (.epw).

C. Set the grid node: Set the sensing node for calculating the illuminance. The node position is set to the height of the working plane, which is 76cm above the floor. The interval between each node is set at 50cm as recommended.

D. Specify the material: Specify the material in the form of geometry in the space for the analysis of daylight or energy performance. In order to ensure the accuracy of simulation, the reflectance of indoor material and the transmissivity of glass in this study take the reflectance of office space materials recommended by IES as the base value. The material settings are shown in Table 1.

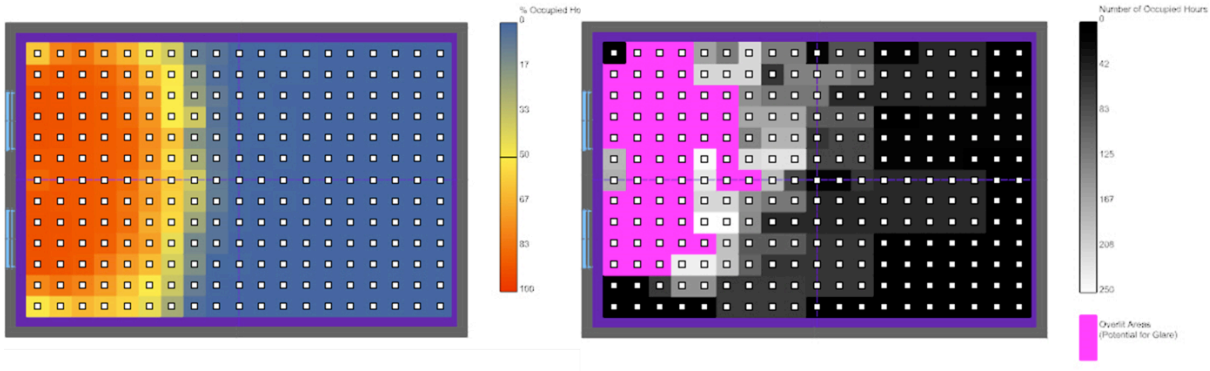


Figure 1: simulation results of DIVA dynamic lighting indicators (left: sDA; right: ASE)

Table 1: Material reflectance and glass transmittance setting

Ceiling reflectance	Wall reflectance	Floor reflectance	sunshade light guide reflectance	Glass transmittance
70%、80%	50%、70%	20%、40%	90%	80%

Process and Result of Research

1. Research object and space setting

There are two main problems in the design of natural daylighting in office space: (1) poor uniformity of illumination. Due to the deep depth of the office space, the gradient of spatial illumination becomes larger. If the illumination at the window position is relatively high, the indoor illumination would be relatively low. (2) Glare on the working plane. Since the illuminance value at the window position is high, and the problem of glare is prone to occurring, the visual discomfort is more likely to happen on users. In order to solve the above two problems, this study will carry out the natural daylighting simulation of the reflectance of window opening type, sunshade light-guide device and material, in order to improve the spatial daylighting.

In this study, the common office space building model is taken as the reference, and the unit space size is set by a multiple of 3 m. The space size for the simulation is set to be 6m wide and 9m deep, and the space height is set to 3.6m.

Based on the reflectance of the building material, the position of the inner and outer sunshade light guiding system, or the presence or absence of the sunshade light guiding system, each type of the office unit space will undergo 8 sets of dynamic daylighting simulation. Simulation No. 01 and 02 are conducted with the presence or absence of external sunshade. No. 03 and 04 are conducted with the conditions that the internal or external light guide plate is set up to import more uniform light. No. 05 to 08 feature the external sunshade and internal "light guide" to test the ceiling reflectance, wall space reflectance and floor reflectance respectively.

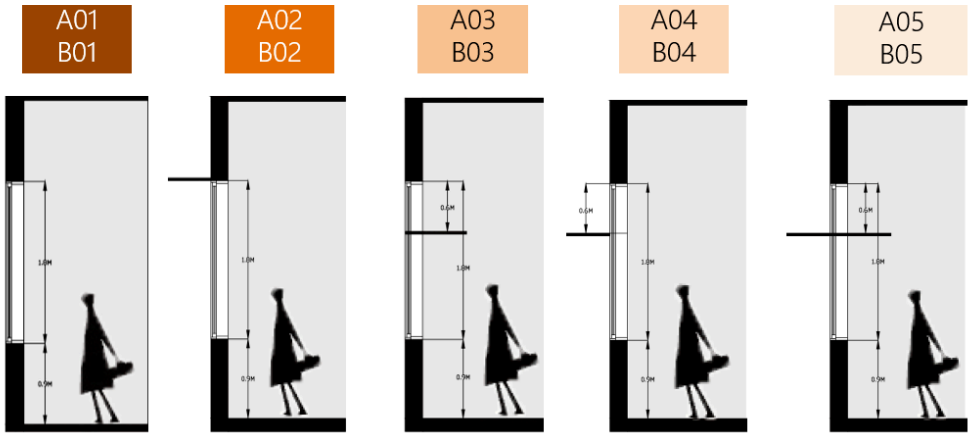


Figure 2: Sunshade and light guide device settings

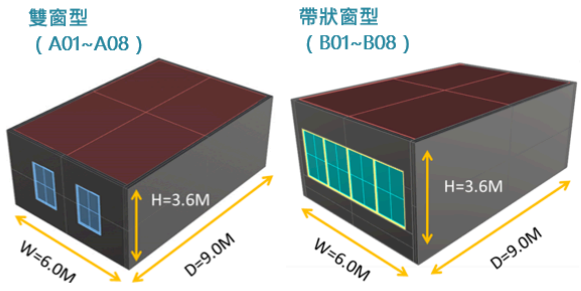
2. Dynamic Daylight Simulation of Unit Type Office Space: Single-sided Window opening (take the south orientation as an example)

In this research, the unit type office space is divided into two types of window modes: "double window type" and " ribbon window", and different sunshade light guiding forms of window opening and indoor material reflectance. The biggest difference that

separates the ribbon window from double window in terms of daylighting lies not only at the large opening area of the ribbon window, but also at the continuous ribbon-shaped daylighting, resulting in the relatively light contrast between the brightness and darkness in the room. Thus, the uniformity will also be better.

(1) Influence of "double window" and "ribbon window" on dynamic daylight

Taking the south-oriented window opening as an example, the daylighting simulation results of the double window type and the ribbon window are shown in the table. The total window opening area of the ribbon window type is about 2 times that of the double window type, and the sDA value is also about twice that of the double window type. However, if the 55% of sDA value is taken as the base value of the amount of indoor daylighting, under the current single window opening condition, neither the double window type nor the ribbon window type can achieve the ideal amount of daylight during the working hours. In the aspect of the ASE value, the value of ribbon window type is about 3% higher than the double window type. Especially if the window opening is equipped with a sunshade light guide device, the ASE value can be below the recommended value of 10%. Overall, B07 is the model that is the closest to the ideal daylighting state.



Double window type (A01~A08)

Ribbon window type (B01~B08)

Figure 3: Simulation model

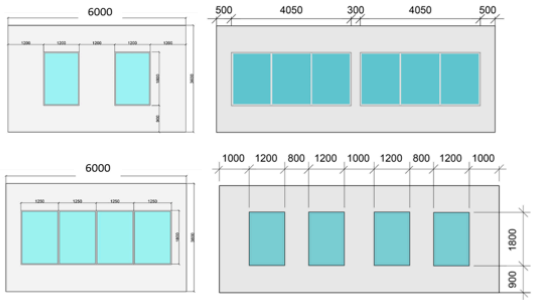


Figure 4: Facade setting of simulation models

Table 2: sDA and ASE of double window type office (south orientation)

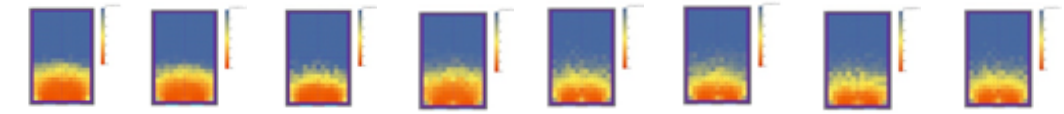
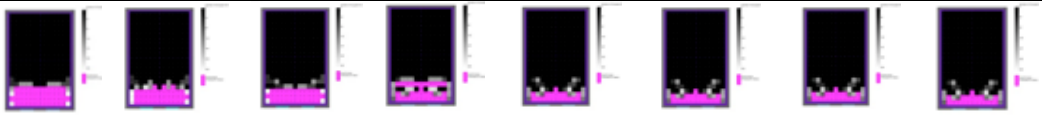
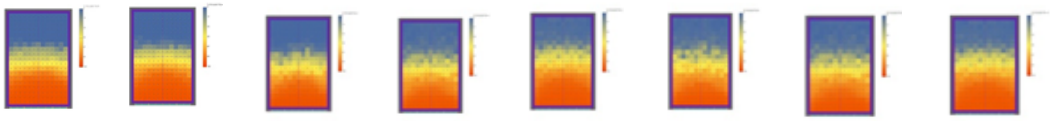
reflectance	A1	A2	A3	A4	A5	A6	A7	A8
ceiling	70%	70%	70%	70%	70%	80%	70%	70%
wall	50%	50%	50%	50%	50%	50%	70%	50%
floor	40%	40%	40%	40%	40%	40%	40%	20%
sDA								
	28.7%	28.7%	22.7%	27.5%	19.8%	19%	20.2%	19.8%
ASE								
	18.6%	15%	14.2%	12.1%	7.7%	7.7%	7.7%	7.7%

Table 3: sDA and ASE of ribbon window type office (south orientation)

reflectance	B1	B2	B3	B4	B5	B6	B7	B8
ceiling	70%	70%	70%	70%	70%	80%	70%	70%
wall	50%	50%	50%	50%	50%	50%	70%	50%
floor	40%	40%	40%	40%	40%	40%	40%	20%
sDA								
	42.9%	45.7%	45.7%	49%	44.5%	46.6%	47%	44.5%
ASE								
	21.5%	18.2%	15.8%	18.2%	10.5%	10.5%	10%	10.5%

(2) Influence of the sunlight guiding device on dynamic daylighting

In the case of double window type with the absence and presence of sunshade, the sDA values are both 28.7%, but the ASE value is about 3% lower when there is the external sunshade device. In contrast, when the ribbon window is equipped with the ribbon horizontal external sunshade device, the sDA value, affected by the diffuse reflection ray of the device, is increased slightly by about 3%, and ASE is decreased by about 3%.

If the sunshade light guiding device is installed indoors, or extends beyond the inside of the room to the outside, the sDA of double window type will continue to drop, which is not conducive to the overall natural daylighting amount inside the room. However, the light guiding sunshade device is beneficial to the increase of the sDA value of the ribbon window type, because the light guiding sunshade device is installed between the clerestory and the general window, thus making the effects of light guiding and diffuse reflection ray the best.

(3) Influence of indoor material reflectance on dynamic daylighting

In general, if the indoor material has a high reflectance, it will help the light diffuse in space and improve the quality. However, when we observe the simulation results of overall dynamic daylighting, compared to the original control group (the ceiling reflectance is 70%, the wall space reflectance is 50% and the ground reflectance is 20%), the increase in reflectance of the indoor material exerts almost no effect on the sDA value and ASE value. Only when the wall space reflectance is increased to 70%, the sDA value rises slightly.

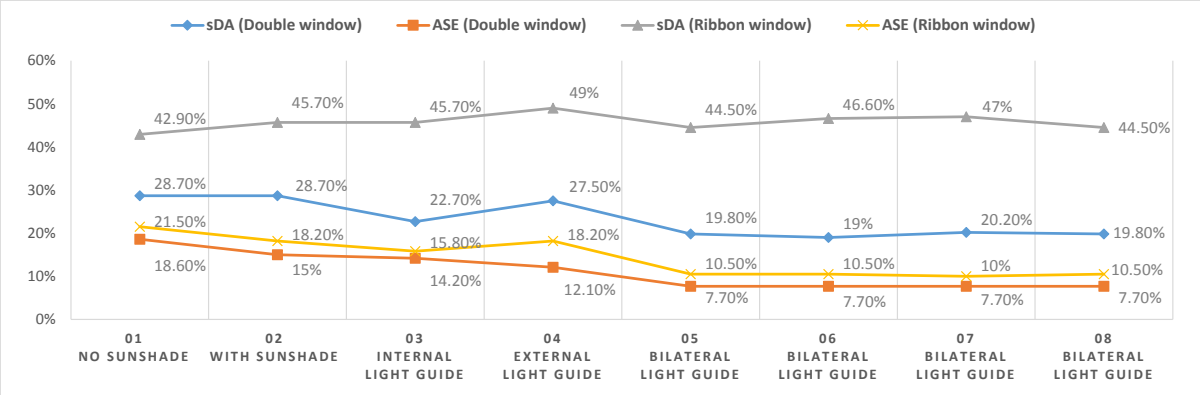


Figure 5: Simulation results of sDA and ASE with double window and ribbon window

3. Simulation of Dynamic Daylighting of Unit Type Office Space: Single-sided Window Opening (All Orientations)

(1) Double-window type

This study further simulates the dynamic daylighting of the double-window type and the ribbon window type, and the sDA and ASE values are shown in the table. Compared with the A01 and A02 of each orientation, except the sunshade of the south-oriented window, the sDA value will be reduced by 1.2% to 3.6% when there is a sunshade device, and the north-oriented window without the sunshade device features the highest sDA value, which is 36.4%. But the standard value of 55% still fails to be reached, requiring the daylighting to be improved. The north-oriented window features the best ASE value, all below the standard value of 10%. What follows is the A02 with sunshade in the south, and its ASE value is 15%. The ASE values of the west-oriented windows are all relatively high. The installation of a sunshade device can reduce the ASE value of each orientation by 1.6% to 4%.

In comparing the A01 to A05 of each orientation, the sDA value of the A01 without sunshade device is higher than the other window type, and the A03's inner light guiding device will reduce the sDA value by 5.2% to 7.3%, which is not conducive to the improvement of natural daylighting. The north-oriented window features the best ASE value. Regardless of the light guide device, the ASE value is always kept at 0%, lower than the standard value of 10%. What follows is the A05 with the double-sided light guide plate installed in the south and east orientations. It has an ASE value of 7.7% lower than the standard value of 10%, which is within the range of sound performance.

Take the sDA300lux value of 55% as the standard, the double-window type A01 without sunshade can reach a daylighting depth of about 4m in the north orientation, 3.5m in the east and west orientations, and 3.2m in the south orientation. The A05 installed with double-sided light-guide device features the daylighting depth of about 2.4m in the east and north orientations, and about 3m in the south and west, indicating that the installation of double-sided light device tends to lower the amount of daylighting, especially for the north orientation. For the purpose of sound daylighting, the installation of light guide sunshade device is not recommended for the double window type unit.

Table 4: Dynamic lighting simulation results of all orientation of double window

Orientation		A1	A2	A3	A4	A5	A6	A7	A8
East	sDA(%)	32.8	31.6	26.3	27.9	19.0	19.0	19.4	19.0
	ASE(%)	17.8	16.2	13.4	13.4	7.7	7.7	7.7	7.7
West	sDA(%)	33.2	29.6	25.9	26.3	20.2	19.0	20.2	20.2
	ASE(%)	20.2	16.2	15.4	14.2	9.3	9.3	9.3	9.3
South	sDA(%)	28.7	28.7	22.7	27.5	19.8	19.0	20.2	19.8
	ASE(%)	18.6	15.0	14.2	12.1	7.7	7.7	7.7	7.7
North	sDA(%)	36.4	33.6	31.2	32.0	23.1	21.9	24.3	22.3
	ASE(%)	0	0	0	0	0	0	0	0

(2) Ribbon-window type

Compared with the B01 and B02 of each orientation, except the sunshade of the south-oriented window, the sDA value will be reduced by 2% to 6% when there is a sunshade device, and the north-oriented window without the sunshade device features the highest sDA value, which is 59%. But the standard value of 55% still fails to be reached, requiring the daylighting to be improved. The north-oriented window features the best ASE value, all below the standard value of 10%. What follows is the B02 with sunshade in the south, and its ASE value is 18.2%. The ASE values of the west-oriented windows are all relatively high. The installation of a sunshade device can reduce the ASE value of each orientation by 3.3% to 4.4%.

In comparing the B01 to B05 of each orientation, the sDA value of the B01 without sunshade device is higher than the other window type, and the north-oriented g non-shading sDA value is optimally 59%. In addition to the south, the light guide will reduce the natural light in the indoor space, while the south-oriented outer light guide B04 will increase the sDA value by 6.1%.The north-oriented window features the best ASE value. Regardless of the light guide device, the ASE value is always kept at 0%, lower than the standard value of 10%. What follows is the B05 with the double-sided light guide plate installed in the south and east orientations. The ASE value of 10.5 is close to the standard value of 10%, and it can be achieved with a slight improvement.

Take the sDA300lux value of 55% as the standard, the ribbon-window type B01 without sunshade can reach a daylighting depth of about 5.7m in the north orientation, 5m in the east and west orientations, and 4.5m in the south orientation. The B05 features the daylighting depth of about 5.5m in the north orientations, and about 4m in the south and west, indicating that the installation of double-sided light device tends to lower the amount of daylighting, especially for the north orientation.

Table 5: Dynamic lighting simulation results of all orientation of ribbon window

Orientation		B1	B2	B3	B4	B5	B6	B7	B8
East	sDA(%)	51.8	49.0	47.8	49.0	47.8	46.6	47.8	46.6
	ASE(%)	33.2	28.3	27.9	31.6	25.5	25.5	25.5	25.5
West	sDA(%)	51.4	49.4	49.0	51.4	47.8	46.6	48.2	47.8
	ASE(%)	36.4	32.0	30.4	32.4	27.1	27.1	27.1	27.1
South	sDA(%)	42.9	45.7	45.7	49.0	44.5	46.6	47.0	44.5
	ASE(%)	21.5	18.2	15.8	10.5	10.5	10.5	10.5	10.5
North	sDA(%)	59.0	53.0	53.4	53.8	51.0	50.2	53.0	51.0
	ASE(%)	0	0	0	0	0	0	0	0

4. Dynamic daylighting simulation of unit type office space: double-sided window opening

According to the above simulation results, if only one side within the single space can be used for daylighting, the sDA must be more than 55% and the ASE be less than 10% simultaneously. It is almost impossible to meet these two requirements at the same time, except for the north-oriented window opening, because when the window is opened on one side, the indoor illuminance gradient changes too much, leading the high illuminance to be concentrated in the near-window area. Therefore, the second stage of the daylighting simulation in this study is to test the double-sided window opening, to increase the indoor daylighting amount and improve the indoor uniformity of light and the indoor daylighting conditions.

Considering the design of building daylighting and energy consumption, in the simulation setting of double-sided window opening, the east-oriented and west-oriented window types are the double windows with small aperture opening ratio, and adopt double-sided light guiding device; south-oriented window type is the ribbon window, and the light guiding sunshade type is a double-sided lighting device; the north-oriented window type is a ribbon window, and no light guiding sunshade device is installed. The overall simulation results are shown in the table below.

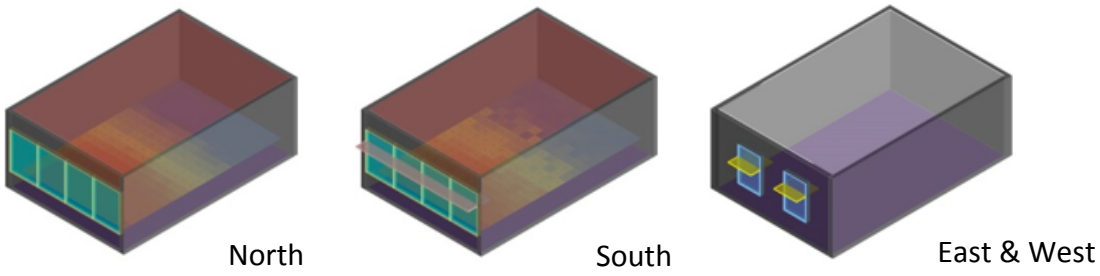


Figure 6: Opening settings of double-sided window simulation

Table 6: Dynamic lighting simulation results of double-sided window

Model scale : 9m(W)*6m(D)			
Window orientation	Window-to-wall ratio (WWR)	sDA(%)	ASE(%)
South & North	18	100	25
East & West	8	21	17
East & North	13	100	9
East & South	13	83	37
West & North	13	100	9
West & South	13	85	38
Model scale : 6m(W)*9m(D)			
Window orientation	Window-to-wall ratio (WWR)	sDA(%)	ASE(%)
South & North	13	100	10.5
East & West	16	92.7	68.8
East & North	15	84.6	19
East & South	15	69.2	31.2
West & North	15	88.7	22.3
West & South	15	72.5	32.8

In general, except for the "East & West"-oriented window opening unit with a width of 9m and a length of 6m, the sDA values of the unit-type double-sided window are mostly above the standard value of 55%, and most of them fall into the category of good daylighting. For the "East & West"-oriented window opening unit with the width of 9m and the length of 6m, the sDA value is only 21%, falling into the category of poor daylighting. The ASE values of the unit type double-sided window opening are mostly above the standard value of 10%, making it the daylighting space prone to glare. The "East & North" and "West & North"-oriented window opening with the width of 9m and length of 6m all feature the ASE values of 9%, below the standard value, making it the daylighting space not prone to glare.

The analysis of dynamic daylighting is conducted on the window opening orientation. Regardless of the combination of space dimensions, the sDA value and the ASE value of the "East & North" orientation are better than the other combinations, followed by the "South & North"-oriented window. The combination of "West & South", "East & South" and "East & West" shows higher ASE value than other combinations.

In terms of space size, a combination of 9m wide and 6m deep is recommended. This space combination shows a ribbon window type for the north-south-oriented window style, and the east-west-oriented window style features the double window type, and the sunshade lighting style is a north-oriented sunshade device, while the south and east-west orientations are installed with the double-sided sunshade light guiding plate.

Since the north-south-oriented double-sided window style can make the sDA value easily reach the standard value of 55%, and the ASE value is relatively lower than other space combinations; the east-west-oriented window style makes the sDA value lower, but can effectively reduce the ASE value, making the ASE value closed to or below the standard value of 10%.

Conclusion and Suggestion

1. The main influence factor of sDA

The window opening area has the greatest influence on the sDA value. What follows is the sunshade light guiding form, but the material reflectance relatively exerts no effect. In a double-window type space, the use of a sunshade light guide reduces the sDA value, but in a ribbon window type space, the sunshade light guide device can increase the sDA value. In addition, the reflectance of the ceiling increases the depth of natural light reflected into the room, while the reflectance of the wall material slightly increases the sDA.

2. The main influence factor of ASE

The sun light guiding device can effectively prevent the occurrence of glare, especially the use of the double-sided light guiding sunshade device can reduce the ASE to below 10%, which is the most important influence factor for ASE. The window opening area has only a slight effect on the ASE, but in a unit space with a small surface, the narrow opening of the window will instead increase the illumination at the window edge, triggering the rise of ASE.

3. Effect of sun light guiding device on space daylighting

The sunshade device is installed for the purpose of reducing the ASE value.The sunshade device needs to be installed in the south-oriented, west-oriented and east-oriented window opening, and there is no need to install the sunshade device in the north-oriented window.

In order to increase the sDA value and decrease the ASE value, a light guide device is required as an improvement method. Regarding the internal light guide plate, the outer light guide plate and the double-sided light guide plate, the external light guide plate can increase the sDA value the most, and the double-sided light guide plate has the best effect of lowering the ASE value. Clients can select the appropriate light guide device based on the demands.

4. Discussion on dynamic daylighting performance of window opening type and window opening orientation

When the window is opened on one side, the ribbon window type has better daylighting performance than the double window type. Especially if the façade of ribbon window type can be matched with the continuous horizontal outer sunshade, it can not only reduce the direct sunlight exposure of the window, but also increase the amount of natural light in the room.

When the window is opened on two sides, the daylighting design should be combined with the external sunshade light guide device to increase the sDA value and reduce the ASE value. The best window opening orientation is the "South & North" space combination, and the worst window opening orientation is "East &West".

Acknowledgements

Thank for Ministry of Science and Technology funding this research (MOST 107-2221-E-035-084).

References

IESNA(2012).Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE), *IES LM-83-12*, IESNA

Kaufman, J.E. et al (1972).*Lighting handbook*. New York : Illuminating Engineering Society.

Köster, H. (2004), *Dynamic daylight Architecture: Basics, Systems, Projects.* Switzerland: Birkhäuser Architecture.

Nabil, A., Mardaljevic, J. (2005). Useful daylight illuminance: A new paradigm for assessing daylight in buildings. *Lighting Research and Technology*, 37, 41-59

Reinhart, C. F., Mardaljevic, J., & Rogers, Z. (2006). Dynamic Daylight Performance Metrics for Sustainable Building Design. Leukos, 3(1), 7-31.

Reinhart, C. F , Walkenhorst , O. (2001). Dynamic RADIANCE-based daylight simulations for a full-scale test office with outer venetian blinds. *Energy and Buildings*, 33(7), 683-697.

Reinhart, C. F.（2014）Daylighting Handbook I. USA: Building Technology Press.

USGBC, (2013) LEED, http://www.usgbc.org/leed

Vine,E., Lee, E. , Clear,R., DiBartolomeo, D., Selkowitz, S. (1998). Office workers response to an automated Venetian blind and electric lighting system-a pilot study, *Energy and Buildings*, 28(2)

Contact email: yucchao@fcu.edu.tw

Study on Partial Discharges Features Evolution of Underground Cable Joints during Insulation Degradation

Chien-Kuo Chang, National Taiwan University of Science and Technology, Taiwan
Chang-Sing Lai, National Taiwan University of Science and Technology, Taiwan
Ruay-Nan Wu, National Taiwan University of Science and Technology, Taiwan

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
Underground cables are significant links in metropolitan power systems. Hence, any cable accident can cause high economic losses and disruption of service to customers. Recently, the condition-based maintenance (CBM) method proposed to improve the weakness of time-based maintenance becomes feasible in smart grid, which optimizes and improves the reliability of power systems. This paper focuses on analyzing the partial discharges evolution during insulation degradation and researching the proper features for the judgement in the status of condition monitoring. The experimental objects are 25 kV distribution underground cable straight joint containing one of two different type of artificial defects. The total experiment are 10 samples set including five defect X and five defect Y. The partial discharge measurement conducts according to the pulse current method of IEC 60270. Through the noise suppression, data simplification and feature extraction methods, each measured data becomes 104 features. By observing the evolution trend of each features, in the final stage the initial phase of the discharge area extends to the area, which is the voltage zero-crossing zone. This phenomenon might develop diagnostic rules for judging the transition of the insulation state, especially for final stage that is about to insulation breakdown. These diagnostic rules could provide the maintenance personnel simple instructions as an early warning for condition-based maintenance.

Keywords: partial discharge, PD, power cable, joint, feature extraction.

iafor
The International Academic Forum
www.iafor.org

Introduction

Underground cables are significant link in metropolitan power systems. Hence, any cable accident can cause high economic losses and disruption of service to customers. However, there are huge amount of cables and accessories such that it takes a lot of time and expense to maintain all of them by traditional method, time-based maintenance (TBM). It becomes more feasible to plan maintenance actions according to inspection and diagnosis conditions, which is called condition-based maintenance (CBM).Cable joint must be constructed on site and it may still have potentially fatal defects. Partial discharge (PD) has been regarded as a condition-based maintenance (CBM) which optimizes the reliability of power systems.

There are two main types of research literature on insulation degradation and partial discharge of underground cables. The first one is to conduct electric tree testing using a test platform composed of the insulation specimen and a needle-plate electrode, and to observe the electric tree image of the insulation specimen by using a charge-coupled device (CCD) camera. This research focuses on the relationship between the amount of partial discharge, the branch structure of the electric tree, and the length of the electric tree. In relevant research results, K. Wu et al. found that the conductivity of the electric tree channel can be regarded as an important factor in the discharge activity. When the electric tree channel changes from non-conductive to conductive due to carbonization, the discharge phenomenon may stop for a period of time until the new channel is generated, and it repeats in this way until insulation breakdown. The entire electric tree growth process can be divided into four stages: PD inception, tree growth, after tree growth stops, and after PD extinction. Ibrahim Iddrissu et al. proposed the fifth stage for the electric tree growth process, called reverse tree growth, to illustrate the phenomenon when the electric tree is very close to another electrode. Through further research, H. Zheng found that there were two different electric tree phenomena in the reverse tree generation process, namely, the filamentary tree and the reverse tree, and the pulse phase of the external partial discharge gradually shifted to the area with high test voltage change rate, that is, near the position where the voltage is 0 degrees or 180 degrees.

The second research is to simulate the defect with actual cable samples, which focuses on the practice of partial discharge measurement and insulation degradation. For example, E. Gulski used defective cable joints to obtain a large number of partial discharge test data, and used data exploration technology to design the threshold value of insulation diagnosis. M. B. Ashtiani et al. made a variety of cavity-sized defects in the cable insulation layer, and then, developed a set of decision tree rules for judging the state of insulation degradation by morphologically taking the features of the partial discharge waveform to reflect the deterioration degree of the insulation state.

In summary, the first type of research is easier to repeat a large number of tests, which can facilitate in-depth understanding of the phenomenon and mechanism of partial discharge and insulation degradation under simple conditions. While the second type of research is more difficult to make test objects, it can obtain data under the conditions of the actual power equipment, and plan the diagnostic rules for equipment maintenance. If the two types of research can be mutually referenced and verified, it may help to clarify the theory and application of partial discharge. The author of this paper has long worked in the second type of research, and through multiple cable tests,

found that from the initial stage to final stage of the degradation test, the phase of partial discharge shifted to the highest voltage/time derivatives, i.e., at zero crossings, which echoes the discovery of the first type of research literature.

This paper focuses on analyzing the partial discharges evolution during insulation degradation and researching the proper features for the judgement in the status of condition monitoring. The total experiment are 10 samples set including five defect X and five defect Y. The partial discharge measurement conducts according to the pulse current method of IEC 60270.

Partial Discharge Experiment:
The experimental objects are 25 kV XLPE cable straight joint. The total experiment are 10 samples. Each joint contains one artificial defects. Two types of defects: Defect X is the shortage of insulation of cable; Defect Y is a hole inside the cable insulation (φ 3 mm, d 4 mm). The partial discharge measurement conducts according to the pulse current method of IEC 60270. The experiments of partial discharges were implement using the high-voltage laboratory of the National Taiwan University of Science and Technology. The partial discharges measurement is constructed according to the pulse current method of IEC 60270, which consists of the capacitive voltage divider, the subject, and the partial discharge measuring device (MD), as shown in Figure 1.

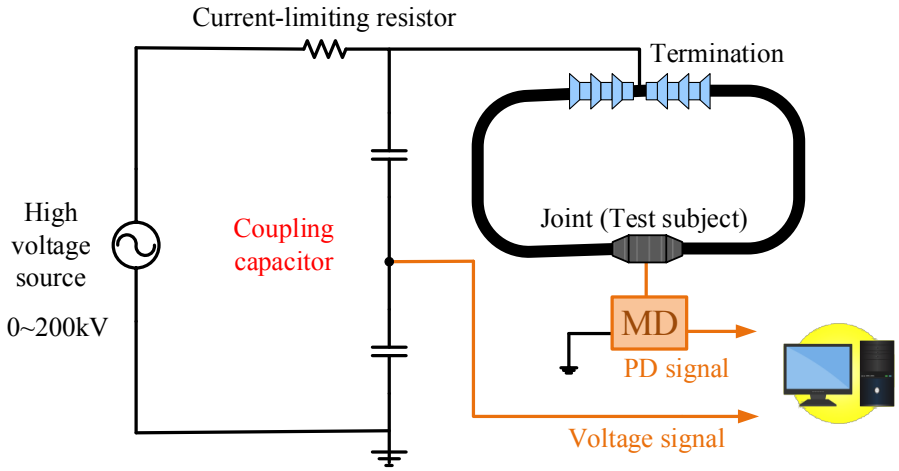


Figure 1: Cable joint experiment and partial discharges measurement.

In the test voltage control, as shown in Figure 2, the method of voltage ascending with resting interval was adopted. The experiment subject was applied from the partial discharge initial voltage (V_{PDIV}) to the breakdown voltage (V_{BR}). The voltage keeps for 2 days and turns off for 1 day (24 hours) and then, raised up in 5kV increments, and so on until the insulation broke down. The reasons for using the ascending voltage is to control the experiment to finish within a feasible amount of time, to avoid the test being too short or too long. To make the sample out of power for one day is to reset the test circumstance intentionally including subsiding space charge if existed. Table 1 shows that the experiment voltages of defect X is from 20 kV to 65 kV and the test voltages of defect Y is from 25 kV to 60 kV.

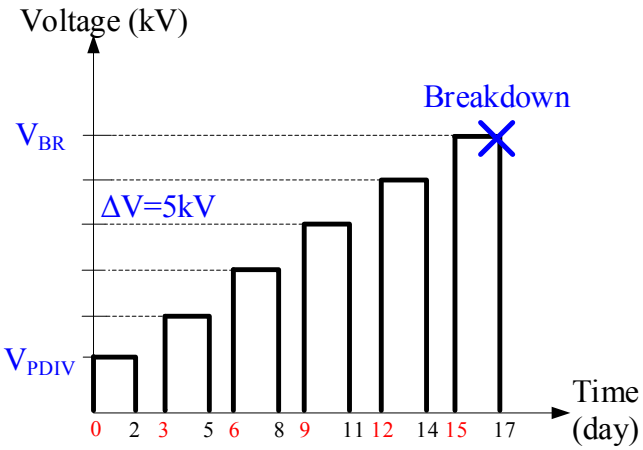


Figure 2: Test voltage control procedure.

Table 1: Test voltage and partial discharge features

Test Sample	Inception voltage (kV)	Breakdown voltage (kV)	Positive phase weight (degree)	Negative phase weight (degree)
X1	20	65	58→2	238→184
X2	20	50	60→18	222→196
X3	20	60	65→12	240→190
X4	20	20	41→28	232→224
X5	20	30	40→27	220→210
Y1	25	30	23→22	220→200
Y2	25	30	33→20	250→198
Y3	25	60	27→20	247→196
Y4	25	30	56→38	250→214
Y5	25	25	33→22	212→197

Figure 3 shows the anatomical schematic diagram and photos of the electric racking experiment objects with broken insulation. It proved that the deliberately-produced defect did induce partial discharges, which was also the inception of discharge position that caused insulation breakdown. Although all discharges began at the defects, the subsequent evolution of the discharge pattern might be different. Hence, they could be classified into two types, namely, the surface type and the electric tree type.

The breakdown trajectory of the surface type started from the defect position on the high pressure side to the outer semi-conductive layer on the low-voltage side via the contact surface of the cable insulation and the joint insulation. The breakdown trajectory of the electric tree type started from defect position on the high-voltage side directly to the insulation of the joint and formed the electric tree; or it formed the electric tree in the joint insulation after a distance through the contact surface of the

cable and the joint insulating, and the electric tree finally extended to the outer semi-conductive layer of the low voltage side.

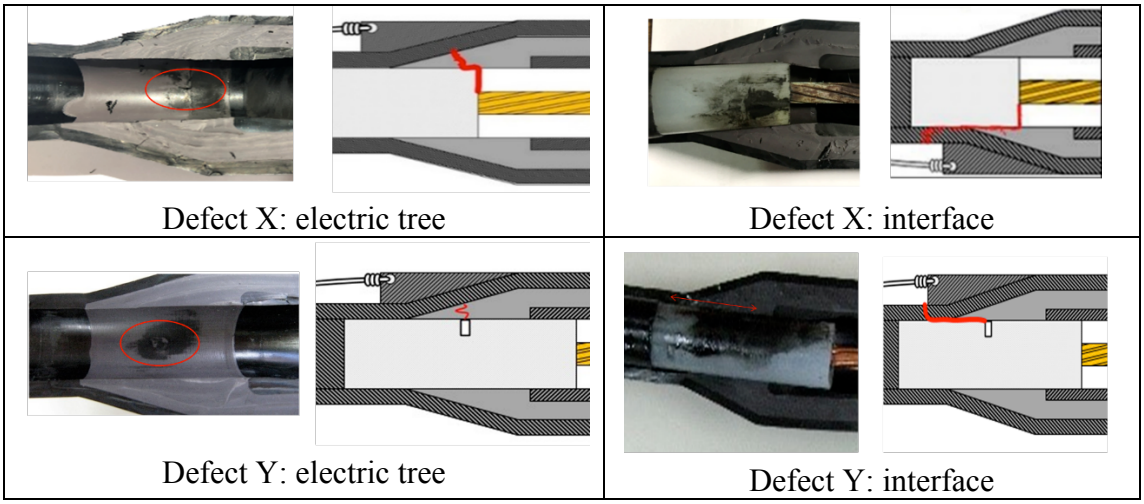


Figure 3: Anatomical photos and the schematic diagram of electric track

In table 1, the phase weight of discharge range (φ_w) of tests has a decline trend. The positive and negative φ_w are approximately 50 and 230° in the initial stage; In the final stage, they decrease gradually and approach the quadrant boundaries of 0 and 180°. The equations of phase weight of DPR (φ_w) is described as Equation (1)

$$\varphi_w = \frac{\sum_{t=1}^{T}\sum_{\varphi=1}^{\Phi}(\varphi \times q(t,\varphi))}{\sum_{t=1}^{T}\sum_{\varphi=1}^{\Phi} q(t,\varphi)} + \varphi_{ini} \quad \text{.....(1)}$$

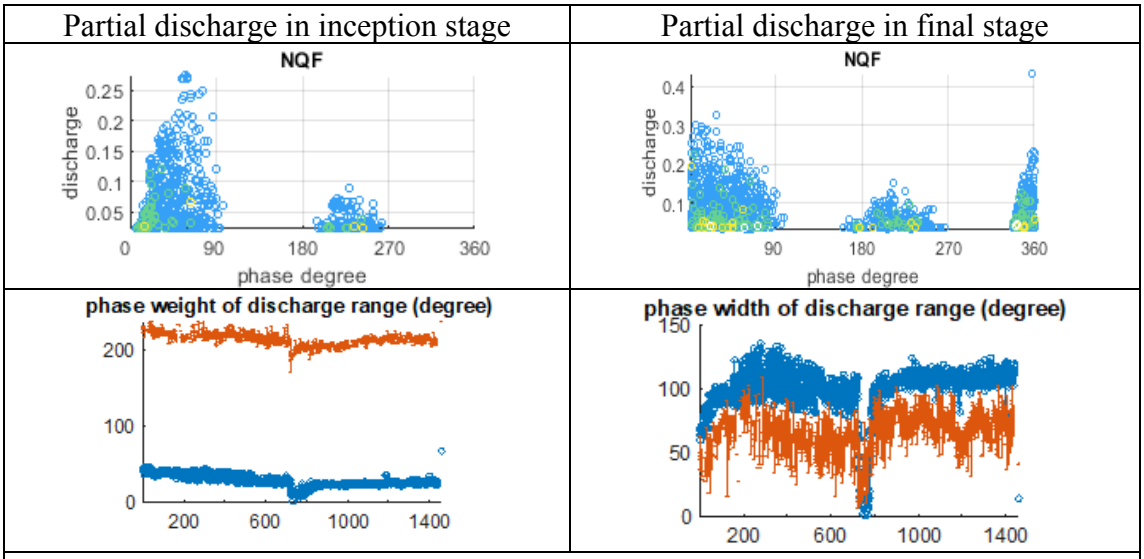
where,

$q(t,\varphi)$*: discharge magnitude in phase window* φ *in the electric cycle t.*

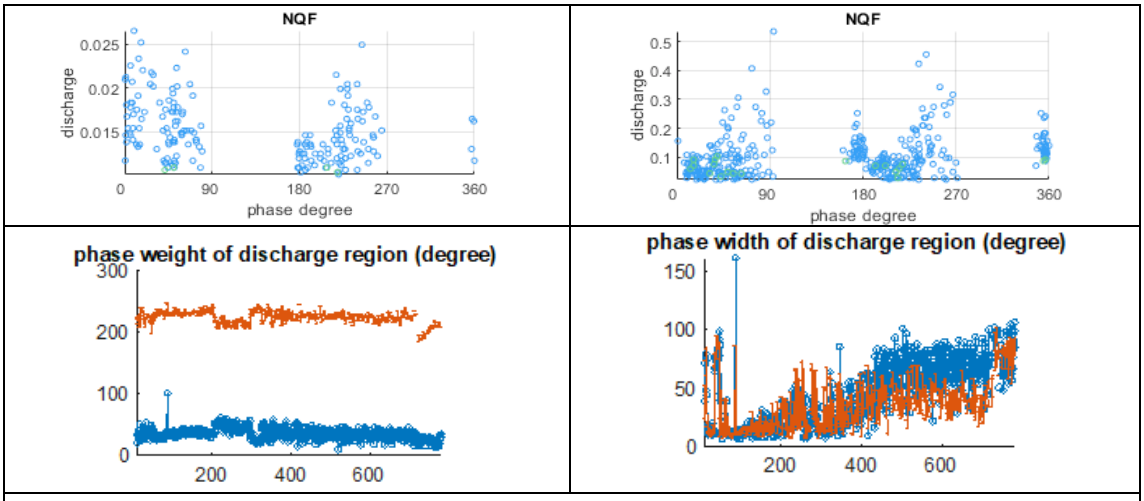
T: total number of electric cycles, 40.

Φ *: total number of phase windows in one electric cycle, 600.*

φ_{ini} *: initial phase of discharge range.*



(a) Defect X5



(b) Defect Y2

Figure 4: Trend of the phase weight of positive DPR and negative DPR

Discussion

According figure 4, it could be found that partial discharges quantities are not always increasing or decreasing, even disappeared for a long time before breakdown. It could be derived that it is too careless to evaluate the overall insulation condition only through the few measurements of the partial discharge data. Hence, long-term measurement data is necessary to develop a comprehensive diagnostic method.

From observing the evolution trend of the feature values, it can be found that, the final stage of the initial phase of the discharge area extends to the area where the voltage variation rate is high, that is, the voltage zero-crossing point, and the discharge area gradually becomes larger. This phenomenon is consistent with the features proposed in literature, and can be used as the basis for judging the transition of the insulation state. Then, after cluster analysis, each test data may be given the definition of the initial stage or final stage of the insulation state.

Conclusion

Since the underground power cable joint must be constructed on site, even if there is a commissioning test after completion test, it may still have potentially fatal defects. For instance, the cavity in the cable insulation may evolve into the electric tree via partial discharges, thereby causing insulation failure. Hence, it is absolutely need to combine online analysis with condition monitoring of the partial discharges and prediction of the breakdown event before occurrence. This paper found that the phase weight of discharge region can be used to recognize the stage of deterioration and these features are independent of discharge magnitude and measurement method.

References

[1] E. Gulski & A. Krivda (1993). Neural networks as a tool for recognition of partial discharges. IEEE Transactions on Electrical Insulation, 28 (6), 984-1001.

[2] W. J. K. Raymond, H. A. Illias & A. H. A. Bakar (2017). High noise tolerance feature extraction for partial discharge classification in XLPE cable joints. IEEE Transactions on Dielectrics and Electrical Insulation, 24(1), 66-74.

[3] H. Hirose, M. Hikita, S. Ohtsuka, S. i. Tsuru & J. Ichimaru (2008). Diagnosis of electric power apparatus using the decision tree method. IEEE Transactions on Dielectrics and Electrical Insulation, 15(5), 1252-1260.

[4] K. Wu, Y. Suzuoki, T. Mizutani & H. Xie (2000). Model for partial discharges associated with treeing breakdown: III. PD extinction and re-growth of tree. Journal of Physical D: Applied Physics, 33, 1209-1218.

[5] Iddrissu, Z. Lv & S. M. Rowland. The dynamic character of partial discharge in epoxy resin at different stages of treeing (2016).Montpellier, IEEE International Conference on Dielectrics (ICD).

[6] H. Zheng, S. M. Rowland, I. Iddrissu & Z. Lv (2017). Electrical treeing and reverse tree growth in an epoxy resin. IEEE Transactions on Dielectrics and Electrical Insulation, 24(6), 3966-3973.

[7] S. S. Refaat & M. A. Shams (2018). A review of partial discharge detection, diagnosis techniques in high voltage power cables. Doha, CPE-POWERENG 2018.

[8] M. Foxall, R. Giussani, M. Seltzer-Grant & B. Sheen (2018). On-line partial discharge condition monitoring strategies for oil and gas high voltage assets optimization. Antwerp, PCIC Europe.

[9] H. M. Pereira (2013). Partial discharge on-line monitoring in MV underground power cables as part of condition based maintenance strategy. Stockholm, CIRED.

[10] Y. H. Lin, R. N. Wu & I. H. Chung (2008). Novel trend of "l" shape in PD pattern to judge the appropriate crucial moment of replacing cast-resin current transformer. IEEE Trans. Dielectr. Electr. Insul., 15 (1), 292-301.

[11] R. N. Wu & C. K. Chang (2011). The use of partial discharges as an online monitoring system for underground cable joints. IEEE Transactions on Power Delivery, 26(3), 1585-1591.

Contact emails: chienkuo@ntust.edu.tw

Role of Corporate Social Responsibility in Hospitals to Improve Environmental Sustainability

Pavithra Priyadarshini Selvakumar, University of East Anglia, United Kingdom

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
Businesses have started integrating CSR as a critical strategy in their core operations, plans, and activities to promote sustainability. Hospitals are one such domain where it is inevitable to be socially responsible with its daily operations. It is also essential to understand the impact of environmental CSR initiatives in the context of hospitals. Despite this, there are limited kinds of literature available on CSR in hospitals. This research overcomes the research gap and provides an in-depth understanding of the nature of CSR in hospitals through an exploratory study. This study helps to learn broader lessons on CSR in hospitals by investigating the history and evolution of CSR (literature review), drivers and barriers of the companies to engage in CSR projects and the extent of CSR engagement to bring about environmental sustainability. A qualitative interpretative case-study was conducted on a private corporate company by integrating staff questionnaires and analyzing the available company data and documents. The research showed that the Company had been engaged with various CSR initiatives that hold accountability and responsible attitude towards the company's stakeholders, the environment, the local community as well as our global society. This study identifies 'attaining Health and Safety' as the primary factor influencing the CSR projects and 'the nature of hospital environment' as the critical challenge for adopting CSR projects. Finally, the research lists the various reasons for the Company to engage in environmental projects, thus drawing broader lessons from the research.

Keywords: Corporate Social Responsibility, Sustainability, Environmental Initiatives, Hospitals.

iafor
The International Academic Forum
www.iafor.org

Introduction

In a globalized environment, hospitals are considered to be the most important pillars of society, because of the growing population and its corresponding healthcare needs, resulting in an exponential increase in the demand for hospitals (Feldman & Lobo, 1997; McKee & Healy, 2000). As a consequence, in addition to clinical quality, hospitals are obliged to be socially responsible, to transcend local moralities and promote transnational values that are in accordance with international conventions of human rights and the abstention of environmental damage (Brandão, Rego, Duarte, & Nunes, 2013). Hospitals have evolved to engage in extensive programs relating to research and development, education and training, scientific and technological progress and other social wellbeing activities to promote cultural globalization, economic growth and social stability as well as environmental protection (Rechel, Wright, & Edwards, 2009). Hospitals are now acting more sustainably and responsibly, aiming for greener development, resulting in fewer environmental damages to society (Burger & Newman, 2010).

Simultaneously, the term Sustainable Development (SD) has gathered significant momentum in the operation of hospitals. The concept is viewed as the future viability of society, which integrates the social, environmental and economic goals within a single framework (Crawford & Scaletta, 2006; Weisz, Haas, Pelikan, & Schmied, 2011; Williams, 2005) Hence, in today's world of intense global competition, it is critical to achieve SD in hospitals, and Corporate Social Responsibility (CSR) is recognized as an effective tool for achieving this (Baumgartner, 2014; Behringer & Szegedi, 2016). CSR is considered as the actions that promote social good, beyond the interests of the organization (Carroll, 1999). Various definitions identify CSR as an ethical (Gupta, 2010), humane (Matthiesen & Salzmann, 2017) and transparent (Dubbink, Graafland, & Van Liedekerke, 2008) way of doing business (Van Marrewijk, 2003). However, the extensive discussions, different phenomena, conflicting goals and varying objectives of CSR contribute to inconsistencies and ambiguities with the actual meaning and concept of CSR (Fischer, 2004; McWilliams & Siegel, 2001). Also, there are fewer kinds of literature available for CSR in sectors like hospitals, even though they are believed to be crucial as well as being obliged to provide trustable service to society (Jamali et al., 2010). Hence, it is essential to undertake more research about CSR in hospitals to efficiently apply ethical principles and to promote better health care services (Francis, 2001). This research therefore aims to gain a broader understanding of CSR in hospitals through a case-study. The case-study company manages the facilities at the hospital and is thus identified as a case-study with potential scope to investigate CSR.

History and evolution of CSR

From early nineteenth century, the notion of CSR has become increasingly prevalent in businesses (Williams, 2005). It is gaining enormous interest among both scholars and practitioners, resulting in rich and diverse literature investigation (Wang, 2015). However, looking back to the history, the development of CSR concept in academic literature goes through a long way and is likely that notions of CSR have been continuously discussed since the beginning of commercial and corporate life. The year 1917 first witnessed the concept of CSR, when Henry Ford announced that the

aim of Ford Motor company is that "To do as much as possible for everybody concerned, to make money and use it, give employment, and send out the car where the people can use it… and incidentally to make money… Business is a service not a bonanza" (Lee, 2008; Lewis, 1976, p.100). Carroll (2015), the father of CSR, states that, to find the roots of CSR, one has to travel hundreds of years back, even then the signs might be older. However, Bowen (1953) first coined the phrase, Corporate Social Responsibility in his book 'Social Responsibilities of the Businessman' and the company Shell first implemented CSR in 1998 (Saha, 2013). Friedman (1970) introduced the concept of 'stewardship' in CSR, explained how managers protect the interests of stakeholders and briefed the various benefits from adopting CSR in businesses. During the 1980s, the Stakeholder theory (Hannan & Freeman, 1984) came in to the picture of CSR, which eventually facilitated the understanding of relationship between CSR and SD during 1990s. By the beginning of 21st century, countries around the globe started framing guidelines, regulations and principles for adopting CSR as one of the best practices in corporations (Norman & MacDonald, 2004). Elkington (1998) described the triple bottom line in his book 'Cannibals with forks: The triple bottom line' and he states the three core principles of CSR as people, planet and profit. 'People' describe encompasses the social and ethical aspects of an organization, 'Planet' involves the ecological and environmental aspects of CSR, and 'Profit' covers the financial and economic aspects of CSR. These three aspects forms a balanced entity of CSR resulting in a new dimension called the Triple Bottom Line, which has given rise to the modern concepts of CSR such as Corporate Citizenship, Corporate Stakeholder responsibility and Political CSR (Elkington, 2013). The last decade witnessed an extensive discourse of CSR, and companies have started to take more social obligations (Muller-Camen & Elsik, 2014).

At present, CSR is becoming a significant global concern because of corporations' interest to integrate social and environmental responsibilities into their daily activities of business to produce an overall positive impact on the society (Chen & Bouvain, 2009). Also, Renaud-Coulon (2014) opines on the need to educate and spread the awareness of CSR among the stakeholders around the world. Nishandar (2015) claims that it is not possible for the Government to address all the social concerns. Hence, he recommends the Corporates to come into the picture and provide solutions for social issues (ibid). However, throughout the evolution, there has been a 'vibrant' discussion on the concepts CSR, where few literatures identify CSR as a concept that is unconnected to businesses (Freeman & Liedtka, 1991); few literatures argue the relevance of CSR to businesses but identify them as a bad idea for an entity to make profit (Friedman & Erdmann, 1962); and, few literatures claim that CSR is of strategic importance to businesses (Farache & Perks, 2010). This discussion on various characteristics of CSR continues till date and complicates the concept of CSR even more (Tilt, 2016). The fact that there is no unique definition emerged in the history of CSR that can be used for all purposes, fosters the need for more intense research in the field of CSR (ibid).

Figure 1 explains the evolution of CSR, its concept and integration of social perspective over the years.

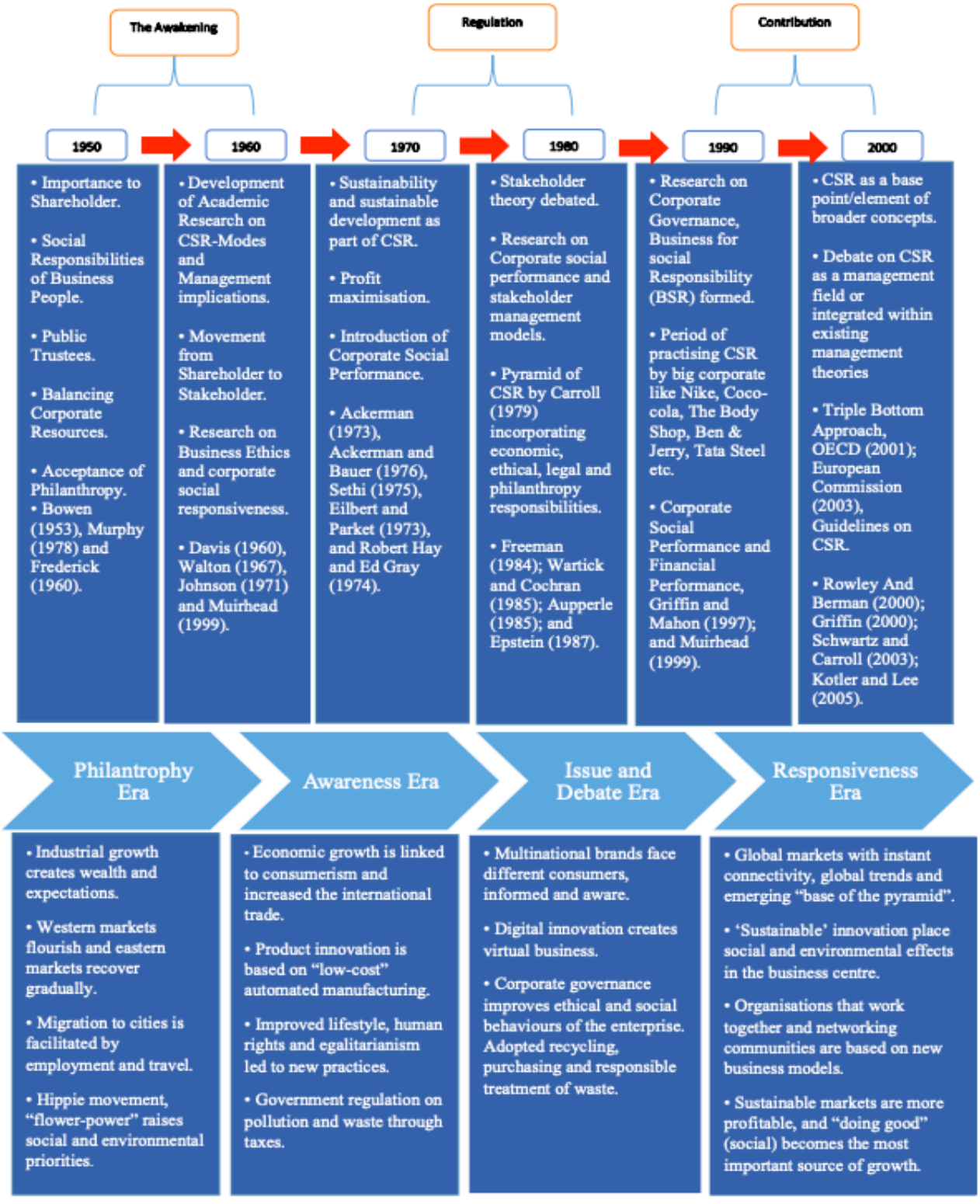


Figure 1: Evolution of CSR and integration of social perspective in timeline. Adapted from (Bhaduri and Selarka, 2016; Popa, 2015)

Various Definitions of CSR Universal or specific definition for CSR is unavailable neither in literature nor in practice (Rahman, 2011). Many CSR definitions were developed by the scholars in the past based on the social, economic, political and environmental context of that period since 1950s (Tilt, 2016). However, various definitions of CSR cover various dimensions including economic development, ethical practices, environmental protection, stakeholders' involvement, transparency, accountability, responsible behavior, moral obligation, corporate responsiveness and corporate social responsibility (ibid).

Table 1 presents the common CSR definitions by various scholars along the timeline.

Sources	**Definition of CSR**
(Bowen & Johnson, 1953, p.6)	"The obligations of businessmen to pursue those policies, to make those decisions, or to follow those lines of action which are desirable in terms of the objectives and values of our society."
(Heald, 1957, p.375)	"Recognition on the part of management of an obligation to the society it serves not only for maximum economic performance but for humane and constructive social policies as well."
(McGuire, 1963, p.144)	"The idea of social responsibilities supposes that the corporation has not only economic and legal obligations but also certain responsibilities to society which extend beyond these obligations."
(Walton, 1967, p.18)	"In short, the new concept of social responsibility recognizes the intimacy of the relationships between the corporation and society and realizes that such relationships must be kept in mind by top managers as the corporation and the related groups pursue their respective goals."
(Carroll, 1979, p.500)	"The social responsibility of business encompasses the economic, legal, ethical, and discretionary expectations that society has of organizations at a given point in time."
(E. M. Epstein, 1987, p.104)	"Corporate social responsibility relates primarily to achieving outcomes from organizational decisions concerning specific issues or problems which (by some normative standard) have beneficial rather than adverse effects on pertinent corporate stakeholders. The normative correctness of the products of corporate action have been the main focus of corporate social responsibility."
(Wood, 1991, p.695)	"The basic idea of corporate social responsibility is that business and society are interwoven rather than distinct entities. Therefore, society has certain expectations for appropriate business behaviour and outcomes."
(European Commission, 2001, p.6)	"A concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis."
(Basu & Palazzo, 2008, p.124)	"The process by which managers within an organization think about and discuss relationships with stakeholders as well as their roles in relation to the common good, along with their behavioural disposition with respect to the fulfilment and achievement of these roles and relationships."
(M. J. Epstein,	"Corporations have become more sensitive to social issues and

2018, p.23)	stakeholder concerns and are striving to become better corporate citizens. Whether the motivation is concern for society and the environment, government regulation, stakeholder pressures, or economic profit, the result is that managers must make significant changes to more effectively manage their social, economic, and environmental impacts."

Having explored other scholars' views and definitions of CSR, due to the close connection with the work nature of the case-study Company, this research inherits the definition of CSR as suggested by the European Commission (2001): "A concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis." The main reason for selecting this definition is because, this research not only focuses on activities that are 'named as' CSR initiatives, but also studies various operations of the hospital that are performed with social and environmental concerns.

CSR in Hospitals

In today's world with the advent of globalization, hospitals play an imperative role by providing effective responses to existing, new and unexpected health care problems. Hospitals, with the mission of providing restorative administrations, are obliged to continually ensure that the welfare of patients remain the utmost primacy while promoting social, economic and environmental equity through CSR initiatives (Siniora, 2017). Despite this, the healthcare industry is facing severe challenges such as a continuous rise in healthcare costs, expanding market demands, emergence of new diseases and the corresponding need for treatments, meeting technological advancements, less public awareness, increasing customer dissatisfaction, high media attention, and shortage of willing and qualified caregivers (Pointer & Orlikoff, 1999). These challenges are intensifying day-by-day and it is far greater than in the past (ibid).

On analysing the top 100 sustainable corporations in the world in the year 2017 from Siemens tops Corporate Knights' 2017 Global 100 ranking, only 11% of the corporations that fall under 'healthcare sector' scored above 90% in several categories pertaining to energy, innovation and human resources (Figure 1) (Corporate Knights, 2018).

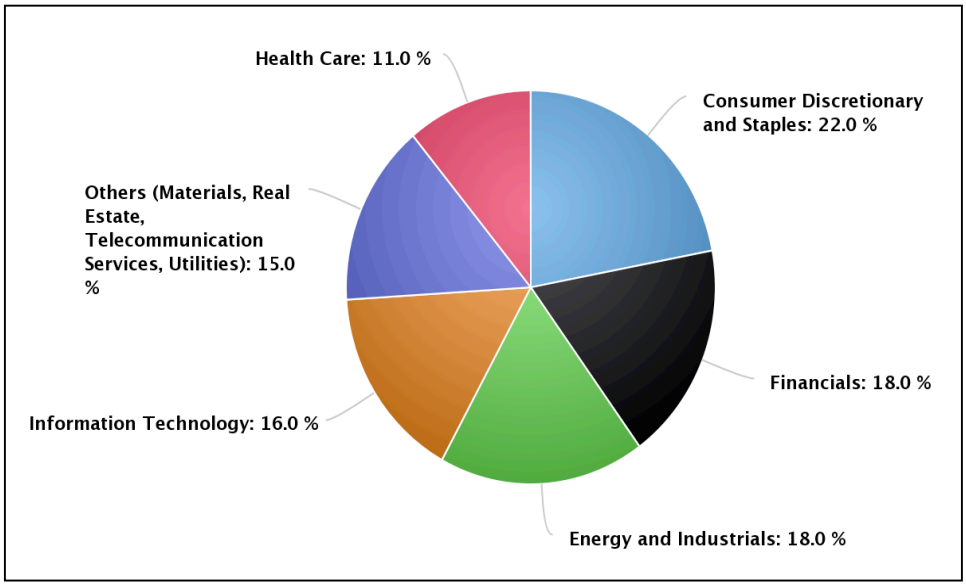


Figure 2: Sector wise indication of top 100 sustainable corporations in the world, 2017
Source: Corporate Knights (2018)

Consequently, World Health Organisation invited hospitals to provide support in fighting against our intensifying global sustainability issues such as climate change and the energy crisis by implementing strict environmental guidelines and regulatory measures (World Health Organisation WHO, 2009). Therefore, hospitals with its negative impact to the global sustainability development, constitute a rewarding field for innovative initiatives for social and environmental wellbeing, as one of the developmental issues of any country (Tehemar, 2012). By proactively implementing CSR in hospitals through awareness creation and holding a number of community events related to medical issues, a number of key benefits are identified such as, brand recognition, higher efficiency, enhanced patient loyalty, economic improvement, and increased support from stakeholders like the Government, customers, shareholders, and business partners (Jamali, Hallal, & Abdallah, 2010). Hence, from the brief literature review, it is evident that CSR in hospitals, if properly considered and implemented, definitely impacts the organization in a positive way and promotes shared values and common ethical principles.

Environmental Initiatives in Hospitals

Hospitals, categorized under service sector, encompass a wide variety of operations, significantly contributing to natural resource depletion and environmental change (McGain & Naylor, 2014). Globally, healthcare sector accounts for one of the biggest environmental footprints when compared with any other industries (Desai & Chandawarkar, 2016). They significantly contribute to excess resource consumption, increased pollution and waste outputs, rising energy costs, and the change in climate that are creating critical challenges for healthcare providers (ibid).

Hence, it is essential to understand the impacts of hospitals on the environment and study the need for 'Corporate Environmental Responsibility' in an hospital environment (Babiak & Trendafilova, 2011; Hancock, 2001). Researches on CSR and environmental sustainability is increasingly converging due to the increasing

environmental concerns around the globe (Montiel, 2008). Simultaneously, the businesses have started shifting towards more 'eco-centric' management to establish harmonious relationship with the natural environment in which they are operating (Shrivastava, 1995). With the increase in global warming, the need for achieving sustainable environment has become more prevalent, resulting in numerous environmental regulations to identify and assess the environmental responsibilities (Montiel, 2008; Newell & Paterson, 2010; Unsworth, Russell, & Davis, 2016).

Consequently, Governments have started to impose legislations and environmental policies in the healthcare sector to promote sustainable society and a least interfered climate (Blowfield & Murray, 2008). For example, 'Environmentally Hazardous Chemicals Act 1985 No 14' is passed by the Government of New South Wales for managing hazardous chemicals and providing a flexible legal framework for the assessment and management of environmentally hazardous chemicals and classified chemical wastes in New South Wales (NSW Legislation, 2018). Rugman and Kirton (2000) identified the five levels of environmental regulations namely multilateral, regional, national, sub-national, and municipal for efficient implementation of environmental initiatives. However, there is a minimal research exploring CSR and its environmental initiatives.

Hence, it is evident that CSR initiatives have drawn substantial interest from law and policy makers, and academics, but the CSR engagement with environmental initiatives have received relatively less attention in the academic literatures.

Data Collection

The primary and secondary data for qualitative case-study are obtained from various sources like interviews, observations, and documents (Merriam, 1988). This research gathers both primary and secondary data using various methodologies.

Primary data

Generally, sources for primary data are surveys, interviews, archival records, site investigations, directs observations, participant-observations and physical artefacts (Yin, 2017). In this case-study, primary research has been conducted through interviews as well as site-visits in order to investigate and study the different CSR initiatives at the case-study company. Additionally, the views of employees from different departments, in relation to the research questions were collected, through face-to-face interviews. The interviews were based on the questionnaires, which facilitated to achieve successful results. Due to the unavailability of some of the interviewees at the time of site-visits, the questionnaires were passed to them and the answers for the questions were sent through emails to the Author.

Secondary Data

Generally, sources for secondary data are literatures, reports, web-pages, documents, various studies by government agencies, international organizations or other businesses within the chosen topic (Yin, 2017). In this research, secondary data are collected from extensive literature review, reports, web-pages and findings from similar case-studies in the field of CSR. Information available on the case-study

company's web-site are used to further enhance the credibility of findings from the research.

Conclusion

Various CSR initiatives are analyzed in the case-study company. Table 6 maps the initiatives at the case-study company with the five dimensions of CSR (Dahlsrud, 2008).

Table 2: Different CSR initiatives by the case-study company; Source: The Author

Dimensions of CSR application	**Initiatives by case-study company**
Environmental dimension	Food wastage reuse, woodland green walkway path, recycling system.
Stakeholder dimension	Cycle to work scheme – cheap bicycle, health and well-being group – mental health training and ergonomics.
Social dimension	Project opportunities and in-class work study opportunities for students from local Universities and schools, Job opportunities to people from local region.
Economic dimension	DALI lighting system, efficient waste management system.

Rather than just 'being good' or 'doing good', these initiatives emphasize the importance of sustainability in a hospital environment. On the whole, it is inferred that, CSR activities in hospitals are in a dynamic phase, and it is moving towards a more holistic representation of sustainability. It is also found that, implementing the CSR initiatives have brought positive effects to the hospital such as good reputation of the case-study company within the community, improved customer satisfaction resulting in loyalty, cost reduction and enhanced contribution to environment (Friedman, 1970).

Drivers and barriers of CSR initiatives

Various factors drive the case-study company towards CSR to achieve the four core values of the company – trust, care, innovation and pride. Interestingly, when enquired about the key drivers of CSR initiatives to interviewees from various departments, the responses represented 'multitude aspects' that include legal compliance, diversity management, philanthropy, code of conduct and so on. From the analysis, this variation is mainly due to the fact that each department provides importance to different aspects based on their operational nature. For example, Legal compliance is the important driver of CSR initiative in waste management department whereas cost reduction is the key driver of CSR initiatives in electricity department. However, a list of drivers for CSR initiatives is created by analyzing and consolidating the data from interviews and reviewing it by comparing with the company's current understanding of its role concerning CSR.
Summary of drivers of CSR initiatives:

- **Health and Safety**

One interesting analysis from this case-study is, 'health and safety' is identified as the primary driver of CSR initiatives. During the interview, when questioned about the primary driver of CSR initiatives, among the various options, 7 out of 10 people answered 'others' and specified that ensuring health and safety at the workplace is their main factor for selecting a particular CSR initiative. This is mainly due to the fact that the case-study company operates in the hospital environment where health and safety is given the primary importance.

- **Being a 'good' corporate citizen**

From the analysis, it is found that ethical consideration is one of the important drivers of CSR initiatives at the case-study company. This is evident from various initiatives that encourages the case-study company to identify its expertise and extend support in terms of providing training and opportunities.

- **Increased stakeholder interest**

All the initiatives within the case-study company have established good relations with the government as well as the local communities which eventually strengthened the supplier relationship.

- **Legal Compliance**

Adhering to regulations and compliance to the law has been the conventional driving force for implementing CSR initiatives in hospitals. For example, the disposal of hazardous waste to minimise the environmental impacts is strictly adhered because of the need for legal compliance in the hospitals.

- **Reduced operating cost**

In an environment like hospital, which works 24/7, socially responsible activities (say installation DALI lighting system, segregation of waste) contribute to substantial reduction in operation cost.

- **Innovation and learning**

'Innovation and learning' is identified as one of the potential drivers for improving the ways of carrying out activities at the hospitals and for providing a better social progress. For instance, most of the CSR initiatives studied in the case-study are proposed as a result of innovation and learning by the local University students that resulted in significant improvements in the local community.

Additionally, reduced environmental impacts, good reputation leading to risk reduction and crisis management of the hospitals, long-term sustainability for employees and improved financial performance are some of the factors driving the CSR initiatives in the hospital environment. Interestingly, from analyzing the above factors, it is inferred that all the drivers for initiatives are interconnected and possess significant influence on each other. Example, legal compliance is main driver of waste management system. Whereas, efficient waste management system (say, segregation of waste) save money while reducing the negative impact to the environment which eventually increases the stakeholder interest.

However, Table 3 provides a summary of potential challenges and solutions in implementing effective CSR initiatives in hospitals.

Table 3: Potential challenges and solutions to implement CSR; Source: The Author

Potential Challenges	**Possible Solutions**
Hospital Environment	Hospital environment demands 24*7*365 service. Hence, instead of a separate CSR initiative, it is ideal to implement initiatives within the various business operations of hospitals.
Constantly changing legal compliances	Ensure that the company is constantly updated with any change in legal legislation.
The budgetary limitations	All initiatives should be designed considering the budget and try to implement the initiative in a best way.
Lack of public awareness on being socially responsible	Train, develop, encourage and create awareness among public to take personal ownership for environmental and sustainability issues. Example, energy fact initiatives.
Inadequate evaluation of CSR initiatives.	A proper reporting should be mandated to track and measure the impacts of the initiatives.
Lack of awareness about the inherent hazards caused by improper health care waste management.	Training the staffs continuously on health and safety training. Drawing attention by creating publicity like poster sessions, exhibitions and demonstration.

TABLE 2 The CSR Continuum and Basis of Competitive
TABLE 2 The CSR Continuum and Basis of Competitive

CSR continuum
Source of comp
Form of compe Adv

Engagement of CSR in Environmental Initiatives

One of the interesting inferences from the analysis of definitions (Table 1) is that, the engagement of CSR with environmental initiatives have been given spot light only after 21st century. This indicates that companies are increasingly engaging in initiatives to achieve environmental sustainability. However, when calculating the dimension score for the frequently occurring definitions, Dahlsrud (2008) highlighted that the environmental dimension received a significantly lower dimension ratio than the other dimensions. He argues stating Carroll's (1999) literature review, that the environmental dimension was not included in the early definitions. Hence, it can be inferred that the concern for environmental initiatives as part of CSR has been given less importance in the past and the importance is gradually increasing in recent times.
On analyzing the case-study, it is evident that CSR initiatives pose a huge impact on the climate change as well as global environment. Reducing the ecological footprint has been a main issue for the company and it has been constantly engaging with

environmental CSR initiatives. Following are the ways by which the case-study company improves the environment and engages with environmental sustainability.

- Efficient waste management system by using colour coded bins. Additionally, a close watch of weight of regulated medical waste generation and its disposition is made. This helps to track the waste disposal, which helps to formulate strategies to reduce the waste in the mere future.
- Reduced consumption of energy by using energy efficient lighting system like DALI.
- Regulating the natural resources efficiently. For example, treatment of water and testing it regularly for bacteria like legionella.
- Reduced emission of hazardous substances by performing monthly waste monitoring.
- Using recycled and recyclable materials in the hospital.
- Training and encouraging the staffs to look for additional ways to reduce the firm's environmental footprint.

By performing all these activities, the case-study company directly or indirectly contributes to reduce the carbon footprint, thus addressing the issues related to global warming. On the whole, hospitals are now addressing the effect of climate change due to the operation of hospitals. Hence the physical infrastructure and the facilities are designed in such a way that the hospitals effectively contribute to achieve environmental sustainability.

References

Babiak, K., & Trendafilova, S. (2011). CSR and environmental responsibility: motives and pressures to adopt green management practices. *Corporate social responsibility and environmental management, 18*(1), 11-24.

Basu, K., & Palazzo, G. (2008). Corporate social responsibility: A process model of sensemaking. *Academy of management review, 33*(1), 122-136.

Baumgartner, R. J. (2014). Managing corporate sustainability and CSR: A conceptual framework combining values, strategies and instruments contributing to sustainable development. *Corporate Social Responsibility and Environmental Management, 21*(5), 258-271.

Beddewela, E., Herzig, C. (2012). Corporate social reporting by mncs' subsidiaries in Sri Lanka. Paper presented at Accounting Forum.

Behringer, K., & Szegedi, K. (2016). The role of CSR in achieving sustainable development–Theoretical approach. *European Scientific Journal, ESJ, 12*(22), 10.

Blowfield, M., & Murray, A. (2008). The Impact of Corporate Responsibility.'. *Corporate responsibility: a critical introduction. Oxford*.

Bowen, H. R., & Johnson, F. E. (1953). *Social responsibility of the businessman*: Harper.

Brandão, C., Rego, G., Duarte, I., & Nunes, R. (2013). Social responsibility: a new paradigm of hospital governance? *Health Care Analysis, 21*(4), 390-402.

Burger, B., & Newman, P. (2010). Hospitals and sustainability. *Bentley: Curtin University of Technology, Curtin University Sustainability Policy Institute*.

Carroll, A. B. (1979). A three-dimensional conceptual model of corporate performance. *Academy of management review, 4*(4), 497-505.

Carroll, A. B. (1999). Corporate social responsibility: Evolution of a definitional construct. *Business & society, 38*(3), 268-295.

Carroll, A. B. (2015). Corporate social responsibility: The centerpiece of competing and complementary frameworks. *Organizational Dynamics, 44*(2), 87-96.

Chen, S., & Bouvain, P. (2009). Is corporate responsibility converging? A comparison of corporate responsibility reporting in the USA, UK, Australia, and Germany. *Journal of Business Ethics, 87*(1), 299-317.

Commission, E. (2001). *Green paper: Promoting a European framework for corporate social responsibility*: Office for Official Publications of the European Communities.
Corporate Knights (2018) 2017 Global 100. Available at: *http://www.corporateknights.com/reports/2017-global-100/2017-global-100-results14846083/*(Accessed: 30 May 2019).

Crawford, D., & Scaletta, T. (2006). The balanced scorecard and corporate social responsibility: Aligning values for profit. *FMI Journal, 17*(3), 39-42.

Dahlsrud, A. (2008). How corporate social responsibility is defined: an analysis of 37 definitions. *Corporate social responsibility and environmental management, 15*(1), 1-13.

Desai, P. S., & Chandawarkar, M. R. (2016). Aligning CSR activities of Health Care Sector to Developmental Needs of India. *Journal of Pharmaceutical Sciences and Research, 8*(9), 1008.

Dubbink, W., Graafland, J., & Van Liedekerke, L. (2008). CSR, transparency and the role of intermediate organisations. *Journal of Business Ethics, 82*(2), 391-406.

Elkington, J. (1998). Partnerships from cannibals with forks: The triple bottom line of 21st-century business. *Environmental quality management, 8*(1), 37-51.

Elkington, J. (2013). Enter the triple bottom line. In *The triple bottom line* (pp. 23-38): Routledge.

Epstein, E. M. (1987). The corporate social policy process: Beyond business ethics, corporate social responsibility, and corporate social responsiveness. *California management review, 29*(3), 99-114.

Epstein, M. J. (2018). *Making sustainability work: Best practices in managing and measuring corporate social, environmental and economic impacts*: Routledge.

European Commission, (2001) Green paper: Promoting a European framework for corporate social responsibility, Office for Official Publications of the European Communities.

Farache, F., & Perks, K. J. (2010). CSR advertisements: a legitimacy tool? *Corporate Communications: An International Journal, 15*(3), 235-248.

Feldman, R., & Lobo, F. (1997). Global budgets and excess demand for hospital care. *Health Economics, 6*(2), 187-196.

Fischer, J. (2004). Social responsibility and ethics: clarifying the concepts. *Journal of Business Ethics, 52*(4), 381-390.

Francis, C. K. (2001). Medical ethos and social responsibility in clinical medicine. *Journal of Urban Health, 78*(1), 29-45.

Freeman, R. E., & Liedtka, J. (1991). Corporate social responsibility: A critical approach. *Business Horizons, 34*(4), 92-99.
Friedman, M. (1970). The Social Responsibility of Business Is to Increase Its Profits, New York Time Magazine, 13. In: IX.

Friedman, M., & Erdmann, D. (1962). 1982. *Capitalism and freedom*.

Gupta, A. D. (2010). *Ethics, business and society: Managing responsibly*: SAGE Publications India.

Hancock, T. (2001). Doing less harm: assessing and reducing the environmental and health impact of Canada's health care system. *Can. Coalit. Green Health Care*.

Hannan, M. T., & Freeman, J. (1984). Structural inertia and organizational change. *American sociological review*, 149-164.

Heald, M. (1957). Management's responsibility to society: The growth of an idea. *Business History Review, 31*(4), 375-384.

Jamali, D., Hallal, M., & Abdallah, H. (2010). Corporate governance and corporate social responsibility: evidence from the healthcare sector. *Corporate Governance: The international journal of business in society, 10*(5), 590-602.

Lee, M. D. P. (2008). A review of the theories of corporate social responsibility: Its evolutionary path and the road ahead. *International journal of management reviews, 10*(1), 53-73.

Lewis, D. L. (1976). *The public image of Henry Ford: An American folk hero and his company*: Wayne State University Press.

Matthiesen, M.-L., & Salzmann, A. J. (2017). Corporate social responsibility and firms' cost of equity: how does culture matter? *Cross Cultural & Strategic Management, 24*(1), 105-124.

McGain, F., & Naylor, C. (2014). Environmental sustainability in hospitals–a systematic review and research agenda. *Journal of health services research & policy, 19*(4), 245-252.

McGuire, J. W. (1963). *Business and society*: McGraw-hill.

McKee, M., & Healy, J. (2000). The role of the hospital in a changing environment. *Bulletin of the World Health Organization, 78*, 803-810.

McWilliams, A., & Siegel, D. (2001). Corporate social responsibility: A theory of the firm perspective. *Academy of management review, 26*(1), 117-127.

Merriam, S. B. (1988). *Case study research in education: A qualitative approach*: Jossey-Bass.

Montiel, I. (2008). Corporate social responsibility and corporate sustainability: Separate pasts, common futures. *Organization & Environment, 21*(3), 245-269.
Muller-Camen, M., & Elsik, W. (2014). IHRM's role in managing ethics and CSR globally. In *The Routledge Companion to International Human Resource Management* (pp. 578-588): Routledge.

Newell, P., & Paterson, M. (2010). *Climate capitalism: global warming and the transformation of the global economy*: Cambridge University Press.

Nishandar, V. (2015). Corporate social responsibility-the way ahead. *The business & management review, 5*(4), 127.

Norman, W., & MacDonald, C. (2004). Getting to the bottom of "triple bottom line". *Business ethics quarterly, 14*(2), 243-262.

Pointer, D. D., & Orlikoff, J. E. (1999). *Board work: Governing health care organizations*: Jossey-Bass.

Rechel, B., Wright, S., & Edwards, N. (2009). *Investing in hospitals of the future*: WHO Regional Office Europe.

Renaud-Coulon, A. (2014). Corporate social responsibility: How can learning contribute. *Accessed on, 15*.

Rugman, A. M., & Kirton, J. (2000). *NAFTA, Environmental Regulations and Firm Strategies: An Update with Chapter 11 Cases.* Paper presented at the conference: Strengthening Canada's Environmental Community through International Regime Reform: Twenty-First Century Challenges. Munk Centre for International Studies, University of Toronto. &.

Saha, S. (2013). *Essence of CSR in Modern Society* (Vol. vol.1).

Shrivastava, P. (1995). The role of corporations in achieving ecological sustainability. *Academy of management review, 20*(4), 936-960.

Siniora, D. (2017). Corporate Social Responsibility in the Health Care Sector.

Tehemar, S. (2012). Corporate social responsibility in healthcare. *Healthworks Collective. doi: http://healthworkscollective. com/drtehemar/43791/corp orate-social-responsibility-healthcare-sectors*.

Tilt, C. A. (2016). Corporate social responsibility research: the importance of context. *International journal of corporate social responsibility, 1*(1), 2.

Unsworth, K. L., Russell, S. V., & Davis, M. C. (2016). Is Dealing with Climate Change a Corporation's Responsibility? A Social Contract Perspective. *Frontiers in Psychology, 7*, 1212. doi:10.3389/fpsyg.2016.01212

Van Marrewijk, M. (2003). Concepts and definitions of CSR and corporate sustainability: Between agency and communion. *Journal of Business Ethics, 44*(2-3), 95-105.
Walton, C. C. (1967). *Corporate social responsibilities*: Wadsworth Publishing Company.

Wang, S. (2015). Literature review of corporate social responsibility. In *Chinese strategic decision-making on CSR* (pp. 7-28): Springer.

Weisz, U., Haas, W., Pelikan, J. M., & Schmied, H. (2011). Sustainable hospitals: A socio-ecological approach. *GAIA-Ecological Perspectives for Science and Society, 20*(3), 191-198.

WHO, H. (2009). Health Care Without Harm. Healthy hospitals, healthy planet, healthy people—addressing climate change in health care settings: discussion draft. May 2009. In. Geneva: WHO Department of Public Health and Environment, HCWH.

Williams, A. (2005). Consumer social responsibility. *Consumer Policy Review, 15*(2), 34-35.

Wood, D. J. (1991). Corporate social performance revisited. *Academy of management review, 16*(4), 691-718.

Yin, R. K. (2017). *Case study research and applications: Design and methods*: Sage publications.

Contact email: pavithrapriyadarshini.s@gmail.com

Air Quality-forecasting Impacts from Industrial Sources with an Operational Atmospheric Modelling System. Spain Case Study

Roberto San José, Technical University of Madrid, Spain
Juan L. Pérez, Technical University of Madrid, Spain
Libia Pérez, Technical University of Madrid, Spain
Rosa M. González-Barras, Complutense University, Spain

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
Introducing an integrated software tool to help industrial plants assess the impact of their emissions on air quality in surrounding areas, based on air quality forecasts. It is a tool for mapping the expected exceedances of the EU Air Quality Directive over a large area centered on the industrial plants and the contribution of different emission sources. The system allows identifying in time and space the percentage of inmission concentrations due to industrial plants. The system uses the state-of-the-art of Eulerian models. The air quality forecasting system is highly automated, generating air quality prediction and impact results by each morning for the day following. The zero emission methodology (ON/OFF) has been used. To implement the numerical forecast system, scripts were developed in a Linux environment to automatically execute the various data preprocessor, postprocessors and model codes. Models results are converted to the visualization required format. We present the results of several simulations with 1 km of spatial resolution over Spain. The simulations demonstrate that differences (OFF-ON) show heterogeneity patterns at spatial and temporal scales due to significant topographic diversity and meteorological variations at short distances. The magnitude of these changes in concentration is potentially significant and illustrates the accuracy of the modelling tool and how it can be used in forecasting mode to provide meaningful and relevant information to stakeholders. The results show that the modeling system is capable of determining the impact of emission sources in real time and in forecast mode.

Keywords: Air quality, impact, operational, forecast

iafor
The International Academic Forum
www.iafor.org

Introduction

Accurately estimating the air quality impact of industrial plant is an important issue reflected in the EU Air Quality legislation. The 2002/3/EC Directive of the European Parliament and of the Council of 12 February 2002 related to ozone in ambient air provides information related to short-term action plans at the appropriate administrative levels. In accordance with this legislation, industrial plants are required to have appropriate control systems in place so that air quality impact can be predicted in real-time and forecasting modes. The concept of real-time in our case is related to the fact of taking appropriate decisions in advance to avoid specific exceeds of the EU Directive limits. Following above Directive the responsibility to design of short-term action plans, including trigger levels for specific actions, is the responsibility of Member States. Depending of the individual case, the plans may provide for graduated, cost-effective measures to control and, where necessary, reduce or suspend certain activities, including motor vehicle traffic, which contribute to emissions which result in the alert threshold being exceeded. These may also include effective measures in relation to the use of industrial plants or products. In this application we focus on the possible reduction of industrial activities

The ability to reduce emissions in real-time according to a forecast for a specific area and period of time is very challenging. In the past, the ability to forecast air quality in a timely manner was largely limited by computer power and the cost of vector parallel computers. Nowadays, a cluster system using a number of PC processors largely solves this problem in an economic way but it requires that the architecture of the air quality modelling system is carefully designed first. The new generations of air quality modelling systems are capable to simulate in detail atmospheric process which a few years ago was a quite difficult task. Nowadays, the advances in computer capabilities, the computer power has increased substantially in the last years and the PC based platforms have reached high performance levels. The cluster approaches open new scenarios for many applications and particularly on the atmospheric dynamics simulations. And the substantial increases in the knowledge in the atmospheric process have also conducted to new possibilities.

To develop cost-effective emission control strategies, methods for identifying the relative contribution of sources to air pollution are useful (Ribeiro et al., 2014). Air quality models have been shown to be useful in determining the spatio-temporal distribution of air pollutants, as they describe the transport and dispersion of air pollutants, as well as chemical and physical processes (Zhang, Bocquet, Mallet, Seigneur & Baklanov, 2012). A typical methodology for knowing the impact of emission sources on air quality is the well-known "brute force" (BF) method, in which the results of a "base" air quality simulation are compared with the results of a changed simulation using an altered parameter or data set (Samaali, Bouchet, Moran & Sassi, 2011). The traditional zero-out method (a case of BF) involves running the model twice: first with base scenario emissions (ON simulation) and then without emissions where the input of emissions from the sources to be studied is set to zero (OFFs simulations). The differences between the two simulations (OFF-ON) estimate the impacts or contributions of the sources. This approach has been used extensively in the past to isolate the response to changes in inputs from complex, non-linear systems such as air pollution (Thunis, Pernigotti & Gerboles, 2013).

The air quality modelling system is based on the below equation. It defines the fundamental relationship governing chemistry and transport in the atmosphere is the mass balance or continuity equation for minor species emitted and mixed into the air (primary pollutants) or generated by chemical transformation of such species (secondary pollutants). The equation describes the change of the concentration Ci of species i with time t.

$$\frac{\partial C_i}{\partial t} = P_i - L_i + E_i + \Delta(K\nabla C_i) - \nabla(vC_i)$$

where Pi and Li are the chemical production and loss, respectively, and Ei the emission of the species. K represents the eddy diffusivity matrix and v three-dimensional wind vector.

The emission inventory for the proper spatial domain and for the specific period of time (at high spatial and temporal resolution) is possibly the most delicate input data for the sophisticated meteorological/transport/chemistry models. The accuracy of emission data is much lower than the accuracy of the numerical methods used for solving the partial differential equation systems (Navier – Stokes equations) for meteorological models (Dandou, 2005) and the ordinary differential equation system for the chemistry module (San José et al., 2005). The mathematical procedures to create an emission inventory are essentially two (José et al., 2002): a) Top-down and b) Bottom-up. In reality a nice combination of both approaches offers the best results. Because of the high non-linearity of the atmospheric system, due to the characteristics of the turbulent atmospheric flow, the only possibility to establish the impact of the part of the emissions (due to traffic or one specific industrial plant, for example) in air concentrations, is to run the system several times, each time with a different emission scenario. The system uses the EMIMO model to produce hourly 1 km x 1 km gridded emissions of total VOC's, SO2, NOx, CO and particles (PMs).

Air quality modelling system

An air quality modelling system has three fundamental modules, as can be seen in figure 1.

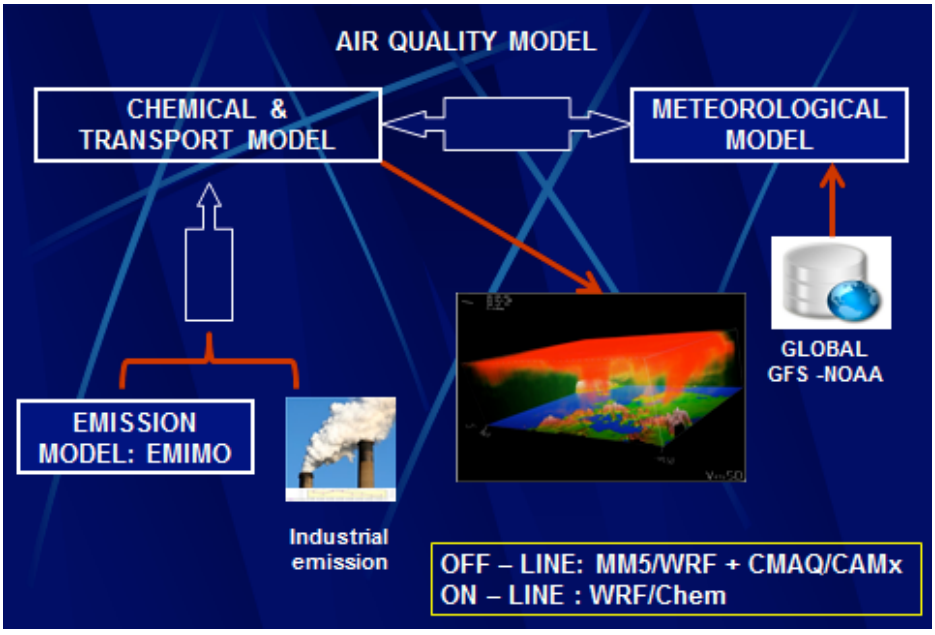


Figure 1: Modules and links for an air quality modelling system.

The chemical and transport module for pollutants, which receives meteorological data and emission data as inputs. The meteorological data are generated by an independent meteorological model or connecting to the chemical module. The meteorological module requires boundary conditions that can be extracted from any global model. Emissions from all sources, including point sources, must be estimated for injection into the atmosphere.

The third generation of air quality models is based on the so-called "one atmosphere" concept. The "One atmosphere" considers the entire atmosphere as a research object, simulating all atmospheric physics and chemical processes at various spatial scales. A commonly used numerical model is the Community Multi-scale Air Quality (CMAQ) modeling system (Byun & Schere, 2006). The meteorological field needed by the numerical calculation of CMAQ is provided by the meteorological models, such as the Mesoscale Meteorological Model 5 (MM5) and the Weather Research and Forecasting (WRF) Model. MM5 is the fifth generation of the National Center of Atmospheric Research/Penn State mesoscale model and WRF is the Weather Research and Forecasting model. MM5 and WRF provide the meteorological input fields for vary air quality models (Appel, Roselle, Gilliam & Pleim, 2010).

In the real atmosphere, chemical and physical processes affect each other. For example, aerosols can affect the balance of atmospheric radiation. Cloud condensation nuclei can also be formed in the cloud, further affecting precipitation. Weather phenomena such as precipitation, wind, or turbulence can affect the Chemical transport and sedimentation process. So, the chemical model is often used in couple with other models. The most popular chemistry coupling model is the WRF/Chem. In the coupled model, the air quality component of the model is fully consistent with the meteorological component; such as, the same transport scheme (mass and scalar preserving), the same grid (horizontal and vertical components), and the same physics schemes for subgrid-scale transport (Grell et al., 2005). WRF-Chem is the Weather Research and Forecasting (WRF) model coupled with Chemistry. WRF is 3-D non-hydrostatic prognostic model that simulates mesoscale atmospheric circulations. Chem model simulates the emission, transport, mixing, and chemical transformation of trace gases and aerosols simultaneously with the meteorology.

EMIMO emission model provides accurate hourly and high spatial resolution (1 km) pollution emission data at global level. Uses data from global emission inventories (TNO-EMEP, EDGAR) and surrogates (Roads, population, land-use) Includes a biogenic module (BIOEMI) for natural emissions European temporal profiles and VOC speciation (Speciate).

To study the impact of a source's emissions on air quality, it is necessary to run several simulations. The flow chart in Figure 2 shows the steps to be performed and the order of their implementation. The first step is to run a meteorology simulation, then the emissions of the base case are estimated, in this case with the active sources, ON and finally the air quality simulation is performed and the reference simulation would be complete. Then, based on the scenarios, the emissions of the source to be studied are adjusted and the air quality simulations are completed with the modified

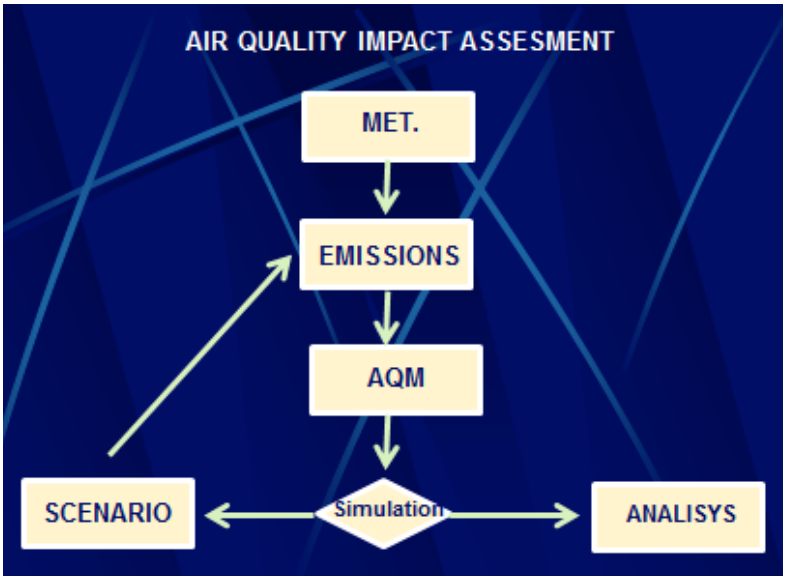


Figure 2: Flow chart of an air quality impact assessment.

The air quality forecasting system is highly automated, generating air quality prediction and impact results by each morning for the day. To implement the numerical forecast system, scripts were developed in a Linux environment to automatically execute the various data preprocessor, postprocessors and model codes. Models results are converted to the visualization required format. Visualization post-processing is done using the Ferret software. The automation of the system is accomplished using TCL and shell scripts.

The web system is based on a combination of data processing programs and visualization tools for the manipulation and visualization of the data produced by the modeling system. The web interface is designed to provide easy access to a wide variety of air quality data produced by the modelling system. The design enables users to explore and analyze datasets in a consistent manner through web services. The tool has a client-server integrated system with a friendly web interface and a modular design which allows optimizing the system to the user requirements. Access is through any standard web browser and HTTP protocol. The user interface and communication dialog is bases on standard HTML, Javascript and PHP, on client side so software requirements are limited to a web browser. The client uses a web browser and the server is running over Linux operating system with the Apache web server. Output maps are dynamically generated that can be interactively controlled and configured by the user. Options include zooming, interactive color scales, animation of dynamic model runs

Results

Before the air quality system starts to predict it is necessary to conduct a process of evaluation and calibration of emissions, to ensure that the system is as accurate as possible. To implement this step, a simulation of at least one year of the past is run, and the results of the model are compared with the results measured by the stations. From this comparison we obtain a series of statistical parameters (bias, root mean square error, correlation coefficient, ...) that allow us to assess the performance of our modelling system. When performing the comparison we must take into account that the data measured by the station are very local and only have validity in a short radius

of influence, while the concentrations predicted by the modeling system correspond to average values of the grid cell that usually have a maximum spatial resolution of 1 km in these systems (San José et al., 2015).

Figure 3 shows a regression analysis between observed data and simulated data corresponding to a Spain case study. It is part of the comparison between ozone observed concentrations at Coslada air quality monitoring station (in the east area of Madrid city, Spain) and modelled with MM5-CMAQ-EMIMO modelling system. The correlation coefficient is 0.854, which is an excellent value that demonstrates a good performance of the air quality modelling system.

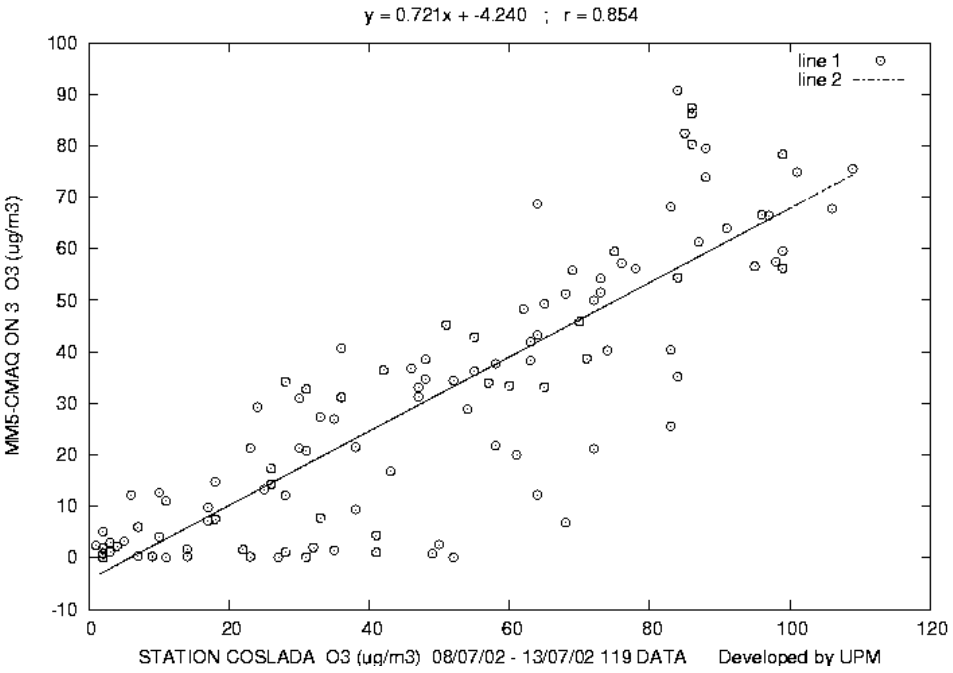


Figure 3: Scatter plot of the modelled and observed O3 concentrations in Coslada monitoring station (Spain) using MM5-CMAQ-EMIMO modelling system.

In Figure 4 we observe how the NO2 impact on the surrounding area for the 24 km domain with 1 km spatial resolution. We observe that there are areas with increases of 10 % and decreases up to 2 %. These nonlinear processes change substantially hour by hour. In this case the forecast is done for May, 21th, at 6:00 GMT over the area. The impacts correspond to a emissions from power plant with 400 MW in an area located at the South East of Madrid Metropolitan Area, Spain. The impacts are calculated using the ON-OFF mode which means that it will simulate the scenario representing the full operation (ON) and the emission reduction scenario without operation (OFF).

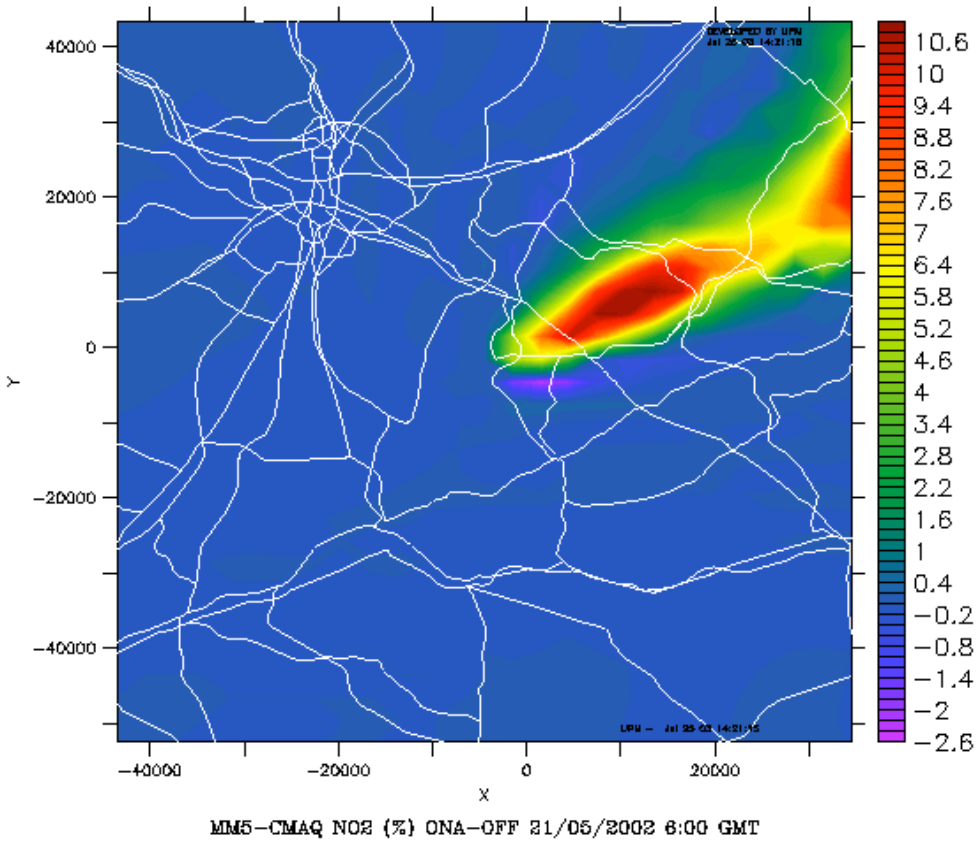


Figure 4: Contribution (ON-OFF) to NO2 concentrations (%) due to emissions of the power plant.

Figure 5 is an example of a Spain case study. The objective was to analyze the contribution of two elevated point sources (plants for waste or residual treatment) to the Madrid air quality. Identifying in time and space the percentage of inmission concentrations due to the industrial plants. The model has been configured with three unidirectional domains of 25, 5 and 1 km of network separation representing Spain, the Community of Madrid and the city of Madrid with its surroundings. Two elevated point sources have been analysed in this study. Both sources are companies whose activity is focused on waste treatment. The base case or simulations ON, all sources emit. The WRF/Chem modeling system, which is commonly used in air quality prediction studies, was implemented to simulate meteorology as well as the dispersion and transport of pollutants. The next is the OFF simulation, whose emissions from sources 1 and 2 are set to zero. Differences between OFF and ON (OFF-ON) simulations report impacts of the two sources when working together. A year of simulation of the designed architecture spent 32,000 CPU hours. For the entire experiment, 300,000 CPU hours have been spent including calibration processes using 1800 cores.

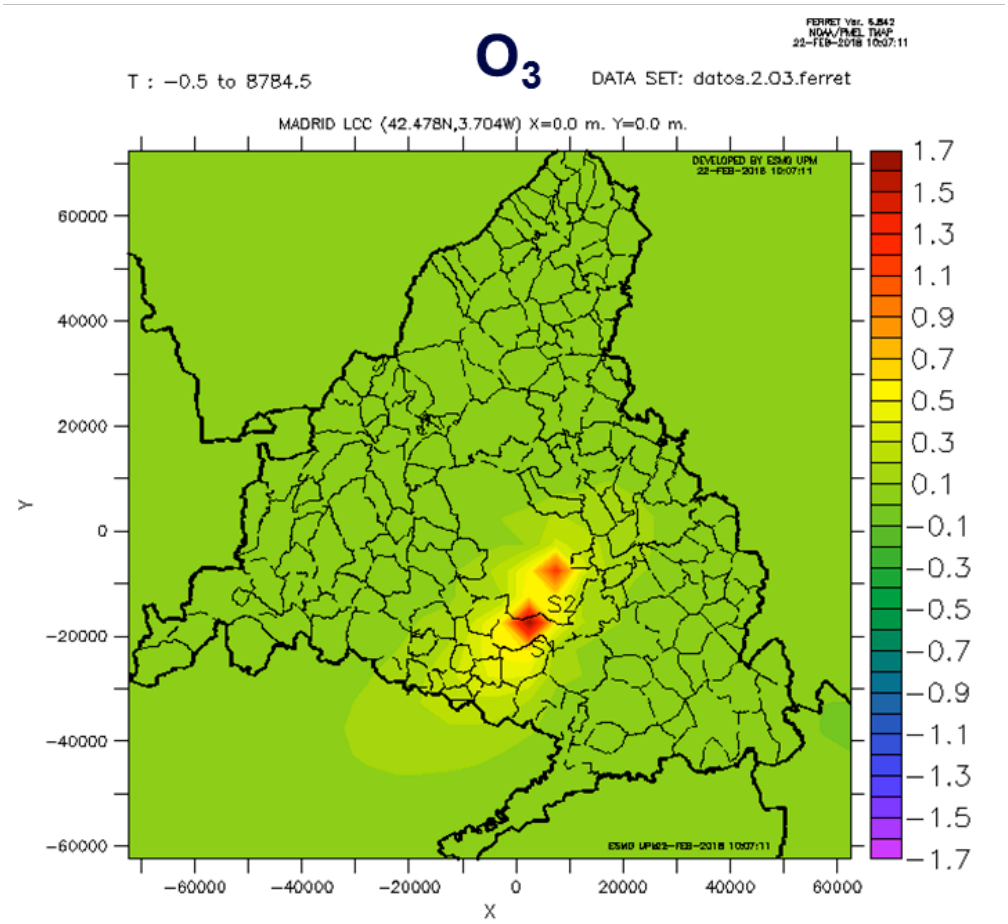


Figure 5: Surface impacts (%) in O3 yearly average concentration of two elevated point sources (OFF-ON).

Fig. 5 shows the impact (%) of the two emission sources on the yearly average concentration of O3. S1 is the source with the largest impact, as its emissions are responsible for decreases in O3 concentrations of up to 1.7 % over an annual average. In areas with NOx emissions, O3 is often decreased locally. Areas close to NOx sources often become O3 sinks. However, the cycle between NO and NO2 is fast and NO2 could be lost through dry deposition and chemistry, and these non-linear processes make it difficult to model NOx and O3 concentrations (San José, Pérez, Morant & González, 2008). The efficiency of emission control depends on the relationship between primary and secondary pollutants, as well as environmental weather conditions. Due to the chemical coupling of O3 and NOx, the levels of O3 and NO2 are closely linked (San José, Pérez, Morant & González Barras, 2009). Therefore, the response to NOx emission reduction is significantly non-linear and any resulting reduction in NO2 level is invariably accompanied by an increase in O3 level (Jose, Perez & Gonzalez, 2008). In addition, changes in the local level of O3 and NO2 will lead to an increase in the background level, so it is necessary to obtain a thorough understanding of the relationships between O3, NO and NO2 under various atmospheric conditions (San José, Pérez & González, 2008).

Conclusions

An integrated software tool to help industrial plants assess the impact of their emissions on air quality, based on air quality forecasts has been presented. The air quality modelling system includes an emission model (EMIMO) and a pollutant transport and meteorological-chemistry models. The air quality forecasting system is highly automated, generating air quality prediction and impact results by each morning for the day. Scripts were developed in a Linux environment to automatically execute the various data preprocessor, postprocessors and model codes.

The modelling system has been used to analyze the contribution of different elevated point sources with high spatial resolution (1 Km) using a ON-OFF methodology. The system allows identifying in time and space the percentage of inmission concentrations due to industrial plants. The system uses the state-of-the-art of Eulerian models. During the last years the system has been installed in a few more industrial plants running operationally in real-time to provide air quality impact services to industrial plant owners and environmental authorities in Spain with full success.

The system has been evaluated using developed scripts for the diagnostics and assessment of air quality model performances. It fulfils all criteria for correlation, bias, standard deviation and, so it can be used for applications. The evaluation of the performance has been very satisfactory. The simulations showed that point source emissions were contributors to exceedances in the nonattainment areas. Also the sources can reduce the number of O3 exceedances.

The differences (OFF-ON) distributions show heterogeneity patterns in spatial and temporal scales due to significant topographic diversity and meteorological variations over short distances. The magnitude of these concentration changes is potentially significant and illustrates that accurate of the tool and how it can be used in forecasting mode to provide meaningful and policy-relevant information for the stakeholders

Acknowledgment

The UPM authors acknowledge the computer resources and technical assistance provided by the Centro de Supercomputación y Visualización de Madrid (CeSViMa). The UPM authors thankfully acknowledge the computer resources, technical expertise and assistance provided by the Red Española de Supercomputación.

References

Appel, K., Roselle, S., Gilliam, R., & Pleim, J. (2010). Sensitivity of the Community Multiscale Air Quality (CMAQ) model v4.7 results for the eastern United States to MM5 and WRF meteorological drivers. Geoscientific Model Development, 3(1), 169-188. doi: 10.5194/gmd-3-169-2010

Byun, D., & Schere, K. (2006). Review of the Governing Equations, Computational Algorithms, and Other Components of the Models-3 Community Multiscale Air Quality (CMAQ) Modeling System. Applied Mechanics Reviews, 59(2), 51. doi: 10.1115/1.2128636

Dandou, A. (2005). Development and evaluation of an urban parameterization scheme in the Penn State/NCAR Mesoscale Model (MM5). Journal Of Geophysical Research, 110(D10). doi: 10.1029/2004jd005192

Grell, G., Peckham, S., Schmitz, R., McKeen, S., Frost, G., Skamarock, W., & Eder, B. (2005). Fully coupled "online" chemistry within the WRF model. Atmospheric Environment, 39(37), 6957-6975. doi: 10.1016/j.atmosenv.2005.04.027

Jose, R., Perez, J., & Gonzalez, R. (2008). An incinerator air quality impact assessment for metals, PAH, dioxins and furans by using the MM5-CMAQ-EMIMO atmospheric modelling system: Spain case study. International Journal Of Environment And Pollution, 32(2), 250. doi: 10.1504/ijep.2008.017105

José, R., Salas, I., MartÍn, A., PÉrez, J., Carpintero, A., & Ramos, M. et al. (2002). Development of A Global-Through-Urban Scale Nested Air Quality Forecast Model (RSM-ANA): Application Over the Madrid Domain. Systems Analysis Modelling Simulation, 42(11), 1551-1560. doi: 10.1080/716067177

Ribeiro, I., Monteiro, A., Fernandes, A., Monteiro, A., Lopes, M., Borrego, C., & Miranda, A. (2014). Air quality modelling as a supplementary assessment method in the framework of the European Air Quality Directive. International Journal Of Environment And Pollution, 54(2/3/4), 262. doi: 10.1504/ijep.2014.065127

Samaali, M., Bouchet, V., Moran, M., & Sassi, M. (2011). Application of a tagged-species method to source apportionment of primary PM2.5 components in a regional air quality model. Atmospheric Environment, 45(23), 3835-3847. doi: 10.1016/j.atmosenv.2011.04.007

San José, R., Pérez, J., & González, R. (2008). The evaluation of the air quality impact of an incinerator by using MM5-CMAQ-EMIMO modeling system: North of Spain case study. Environment International, 34(5), 714-719. doi: 10.1016/j.envint.2007.12.010

San José, R., Pérez, J., Morant, J., & González Barras, R. (2009). The Use of Modern Third-Generation Air Quality Models (MM5-EMIMO-CMAQ) for Real-Time Operational Air Quality Impact Assessment of Industrial Plants. Water, Air, & Soil Pollution: Focus, 9(1-2), 27-37. doi: 10.1007/s11267-008-9196-4

San José, R., Pérez, J., Morant, J., & González, R. (2008). European operational air quality forecasting system by using MM5–CMAQ–EMIMO tool. Simulation Modelling Practice And Theory, 16(10), 1534-1540. doi: 10.1016/j.simpat.2007.11.021

San José, R., Pérez, J., Balzarini, A., Baró, R., Curci, G., & Forkel, R. et al. (2015). Sensitivity of feedback effects in CBMZ/MOSAIC chemical mechanism. Atmospheric Environment, 115, 646-656. doi: 10.1016/j.atmosenv.2015.04.030

San José, R., Stohl, A., Karatzas, K., Bohler, T., James, P., & Pérez, J. (2005). A modelling study of an extraordinary night time ozone episode over Madrid domain. Environmental Modelling & Software, 20(5), 587-593. doi: 10.1016/j.envsoft.2004.03.009

Thunis, P., Pernigotti, D., & Gerboles, M. (2013). Model quality objectives based on measurement uncertainty. Part I: Ozone. Atmospheric Environment, 79, 861-868. doi: 10.1016/j.atmosenv.2013.05.018

Zhang, Y., Bocquet, M., Mallet, V., Seigneur, C., & Baklanov, A. (2012). Real-time air quality forecasting, part I: History, techniques, and current status. Atmospheric Environment, 60, 632-655. doi: 10.1016/j.atmosenv.2012.06.031

Contact email: roberto@fi.upm.es

Energy Substitution Potential in China's Non-metallic Mineral Products Industry-based on the Translog Function and Corrected Formula for Elasticity

Xuguang Wang, China University of Geoscience, China
Liang Yan, China University of Geoscience, China
Xiaoguang Zhao, Northwest Engineering Corporation Ltd. of Powerchina, China
Haroon Qasim, China University of Geoscience, China

The Asian Conference on Sustainability, Energy & Environment 2019
Official Conference Proceedings

Abstract
The non-metallic mineral products industry (NMMPI) of China is the largest in the world and has a character of low energy efficiency, which made this sector energy-intensive and therefore one of leading contributors to CO2 and other pollutants. Therefore, researchers have been paying more and more attentions to the degree of non-energy factors substituting for energy, which is regarded as the most effective measure to address this issue. This study applying the transcendental logarithmic (translog) production function model to investigate the potential of substitution towards energy conservation among production factors in the Chinese NMMPI. Ridge regression is used to estimate the model parameters. Output elasticity and substitution elasticity are calculated. Results show that: during the period 2000-2016, there is significant substitution relationship between energy and capital as well as labor. The elasticities of substitution between energy and capital as well as labor are 1.018 and 1.019, respectively. So, it is possible for the Chinese government to allocate more capital or labor through upgrading technology or implementing policy to realize the CO2 mitigation purpose in the NMMPI. The results of scenario analysis indicate that both capital and labor factors inputs can substitute energy input effectively. In comparison, the substitution effect of labor factor is more obvious.

Keywords: Non-metallic mineral products industry (NMMPI), inter-factor substitution, elasticity of substitution, Translog production function, Ridge regression

iafor
The International Academic Forum
www.iafor.org

Introduction

Massive energy consumption and CO_2 emissions, along with their resulting impacts on the environmental deterioration of China, have caused great concern internationally and domestically(W. Chen, Wu, He, Gao, & Xu, 2007; M. Zhang & Huang, 2012). To control energy consumption without hindering economic development is the biggest challenge for China (Zeng, Ding, Pan, Wang, & Gregg, 2008). The Chinese government has profoundly recognized the severe impact of environmental pollution on the Chinese economy and has elevated environmental governance to an unprecedented level (S. Chen, Chen, Economics, & University, 2018). Pollution prevention and control is prioritized and considered to be one of the three significant challenges in sustainable development of a well-off society. In fact, the Paris Agreement adopted on December 12th, 2015, China, as a contracting party, also proposed some emission reduction targets (Rogelj et al., 2016).

Non-metallic mineral products mainly include cement, refractory materials, flat glass and ceramic products, which are the primary raw materials for the construction industry. Considering the vital role of non-metallic mining products in the national economy, many scholars have listed it as one of the important indicators of economic development in a country or region (Hu & Kavan, 2014). China is the world's largest producer of non-metallic mineral products as well as one of the largest consumers (Lin & Ouyang, 2014). In 2016, China's NMMPI received a sales value of 5998.82 billion RMB (902.43 billion U.S. Dollars) and a total profit of 3789.36 billion RMB (570.05 billion U.S. Dollars) with a year on year increase of 11.2% (2017). The factor efficiency and substitution in NMMPI have significant importance in Chinese economy, as NMMPI is considered to be a pillar industry contributing to about 1% of total GDP every year (Li & Sun, 2018).

Considering one of China's highest energy-intensive industries, NMMPI can effectively contribute to China's energy-saving and emission reduction strategy. Compared with developed countries, China's NMMPI has a substantial gap in factor productivity (Du, Gang, & Chuanwang, 2015). As mentioned in the third section of this article, although numerous studies conducted on energy conservation, but still no research have focused on the factor output elasticity and factor substitution in the NMMPI of China. Ma (Ma, Oxley, & Gibson, 2009) argued that there is lack of research on the estimation of China's energy demand factors and the possibility of substitution between fuels. Guo (Guo & Wang, 2005) stated that the factor substitution has been ignored by Chinese energy economics. Some related literature does exist (see (Fan, Liao, & Wei, 2007; Shi, 2010; Smyth, 2011; Xie, Hawkes, Lund, & Kaiser, 2015; Y. Zhang & Ye, 2014; Y. L. Zhang & A-Zhong, 2013; Zheng & Liu, 2004a)), contributing to China's factor efficiency and factor substitution with preliminary research on limited areas. However, as discussed by Hao (Feng & Statistics, 2015), most of these literatures suffered from formula mis-specification. The substantial gap of energy intensity between China and developed countries indicates that there is an enormous potential of energy conservation (Ouyang & Lin, 2014), however, plenty of work need to be done to achieve this goal. The primary purpose of this paper is to explore the output and substitution issues of input factors of Chinese NMMPI. Findings of this study can be significant regarding the huge potential of energy-saving, the considerable influence of low-carbon transition in China and even the international efforts of reducing greenhouse gases (GHG).

Specifically, this article focuses on the following problems:

- What is the productivity of China's NMMPI input factors?
- What is the relationship between the input factors of China's NMMPI industry?
- Can China achieve substitution between input factors, especially for energy?
- If substitution is available, how much is the extent to which labor and capital can substitute for energy? What effect of such substitution is on the economy?

In this paper, we will 1) sort out the present state of Chinese NMMPI, 2) employ the latest data from the Chinese NMMPI, 3) derive and apply the corrected formula for the elasticity of substitution, and 4) firstly discuss the output and substitution elasticity of the Chinese NMMPI. The results will undoubtedly answer the four questions mentioned above.

A brief synopsis of China's NMMPI

China's NMMPI has been developing rapidly since the introduction of the market economy and the implementation of reforming and opening up policy. Taking the output of cement and plate glass, which are typical products of the NMMPI, as an example, it increases from 680,000 tons and 4.3 million weight boxes in 1955 to 236 million tons and 78,600 boxes in 2015, respectively. As shown in **Fig. 1**, especially since around 2000, the number of products increases rapidly, which was consistent with the acceleration of industrialization and urbanization in China. China had raised the urbanization rate of one-fifth of the world's population from 20% (1981) in the initial period of reforming and opening up to 53% (2012) (Source: *National Bureau of Statistics of China*) during 30 years.

Along with this remarkable figures, massive amount energy consumption also been reported. In 2015, China's industrial industry consumed a total of 2802.06 million tons of standard coal in energy, of which manufacture industry consumed 2489.31 million tons, accounting for 89% of total industrial energy consumption (see **Fig. 2**). NMMPI consumed 350.60 million tons, ranking third in the manufacturing industry, second only to the "ferrous metal smelting and rolling industry" (747.31 million tons) and "manufacture of chemical raw materials and chemical products industry" (483.35 million tons), accounting for 14.1% of the total energy consumption in the manufacturing industry, 12.5% of the total energy consumption in the industrial sector, and 8.2% of the total energy consumption in China (4299.05 million tons). Of the energy consumed in NMMPI, coal (206.4497 million tons) and petroleum (206.67 million tons) accounted for 59.5% of the total energy consumption (Data source: *China Industrial Statistics Yearbook*).

Unfortunately, China's massive energy and resource consumption are resulted by lower energy and resource utilization efficiency. First, taking the cement industry as an example, almost one-third of the cement produced in China is the low-end cement that can only be used domestically. The service life of concrete is generally between 20-30 years, much lower than the standards of developed countries such as Japan, the United States, and the United Kingdom. In recent years, frequent building collapses have been reported in various parts of China. There were many reasons for the destruction of houses, but inferior construction materials were an indispensable incentive. This directly led to a significant amount of waste of resources, accumulating a considerable amount of construction waste that was difficult to handle,

and posing a substantial threat to the environment. Second, waste also contains a vast amount of carbon emissions. As one of the six high-energy industries, carbon emissions from the NMMPI of China accounted for almost one-tenth of that caused by energy consumption all over the country.

Methodology

A twice-differentiable translog production function connecting NMMPI output (*Y*) with capital (*K*), labor (*L*) and energy (*E*) was employed to describe the relations between them as:

$$\begin{aligned}\ln Y_t = {} & \alpha_0 + \alpha_K \ln X_{Kt} + \alpha_L \ln X_{Lt} + \alpha_E \ln X_{Et} + \alpha_{KK}(\ln X_{Kt})^2 + \alpha_{LL}(\ln X_{Lt})^2 \\ & + \alpha_{EE}(\ln X_{Et})^2 + \alpha_{KL} \ln X_{Kt} \ln X_{Lt} + \alpha_{KE} \ln X_{Kt} \ln X_{Et} + \alpha_{LE} \ln X_{Lt} \ln X_{Et} \end{aligned} \quad (1)$$

Where: Y_t: Output of Chinese NMMPI at time *t;* X_K, X_L and X_E: Capital stock, labor and energy consumption at time *t*, respectively; α: Parameters to be estimated. The output elasticity for capital, labor, energy could be respectively written as:

$$\eta_K = \alpha_K + \alpha_{KL} \ln L_t + \alpha_{KE} \ln E_t + 2\alpha_{KK} \ln K_t \quad (2)$$

$$\eta_L = \alpha_L + \alpha_{KL} \ln K_t + \alpha_{LE} \ln E_t + 2\alpha_{LL} \ln L_t \quad (3)$$

$$\eta_E = \alpha_E + \alpha_{KE} \ln K_t + \alpha_{LE} \ln L_t + 2\alpha_{EE} \ln E_t \quad (4)$$

The elasticity of substitution among capital, labor, energy could be respectively written as:

$$\sigma_{KL} = \left[1 + 2\left(\alpha_{KL} - \frac{\eta_L}{\eta_K}\alpha_{KK} - \frac{\eta_K}{\eta_L}\alpha_{LL}\right)(\eta_K + \eta_L)^{-1}\right]^{-1} \quad (5)$$

$$\sigma_{KE} = \left[1 + 2\left(\alpha_{KE} - \frac{\eta_E}{\eta_K}\alpha_{KK} - \frac{\eta_K}{\eta_E}\alpha_{EE}\right)(\eta_K + \eta_E)^{-1}\right]^{-1} \quad (6)$$

$$\sigma_{LE} = \left[1 + 2\left(\alpha_{LE} - \frac{\eta_E}{\eta_L}\alpha_{LL} - \frac{\eta_L}{\eta_E}\alpha_{EE}\right)(\eta_L + \eta_E)^{-1}\right]^{-1} \quad (7)$$

Although the formula for the elasticity of substitution does not seem to be very complicated, it is still difficult to calculate elasticity of substitution concerning the translog production function. The crux of the problem that the model, as shown in (1), contains too many explanatory variables, which makes the collinearity very serious. Although many scholars participate in the research of this problem, there is still no perfect solution. There are three common treatment ideas for this problem: the first is the variable elimination method. Eliminating statistically insignificant variables, but this would undoubtedly undermine "flexibility", which is a core advantage over translog function method. The second is to impose theoretical constraints. For example, if the equation is evaluated under similar conditions, the parameters to be estimated can be effectively reduced, but the constraints may not pass the test. The third is the method of Ridge regression. Although the method pays the price of biased estimation, it can effectively improve the estimation accuracy and is widely used by many scholars.

Data

The time series data from 2000-2015 was selected as a sample for three reasons. First, Although China began to reform and open up in 1978, China's reform and opening up are gradual, both geographically and economically. In other words, it was

not until 2000 that the market economy began to play a leading role in various economic sectors of China (Ding & Li, 2017). The significance of the factor substitution rate depends to a large extent on the energy market structure. If the energy market is not a competitive market but is in a monopoly state, the energy substitution rate will lose its meaning(T. Azomahou, Boucekkine, & Nguyen-Van, 2008). Second, China's resource and environmental problems were not evident before 2000, and they have not received the attention of the society. As can be seen from the Fig. 2, energy consumption began to increase sharply after 2000, but then it entered a period of stability. At the same time, China's environmental deterioration problems started to become more prominent. In particular, the severe smog problem across the country characterized by an unprecedentedly high level of PM2.5 concentrations brought a violent shock to all Chinese people (S. Chen et al., 2018). Then the energy conservation and emission reduction became the consensus of the whole society. The third is that China's national statistical work has also undergone a process of gradual improvement. Under the planned economic system, all economic activities are in compliance with national directives and cannot reflect the real supply and demand situation of the market.

According to the structure of the model, four types of data need to be collected, including output, labor input, capital investment, and energy consumption. Capital investment is measured by the capital stock. Since there is no direct access to the capital stock, the capital stock is obtained by estimation. In general, the method of estimating the capital stock is based on the perpetual inventory method (PIM), which was proposed by Goldsmith in 1951. This method is operable and widely used by scholars. The core assumption is that the relative efficiency uses a geometrically decreasing model. The commonly used estimation models are as follows:

$$K_t = I_t + (1 - \delta_t)K_{t-1} \quad (8)$$

Where, K_t, K_{t-1}represent the capital stock of year $t, t-1$,respectively;while, I_t, δ_t

denote the new investment amount and depreciation rate of year t , respectively. Using this method to estimate the capital stock, the key indicators that need to be determined are shown in the formula: the capital stock of the base year, the actual investment amount series, the industry depreciation rate, and the fixed asset investment price index. The literature (Yong-Ze, Liu, & Zhang, 2017) uses this method to estimate the capital stock of the industrial sector in China. This paper refers to the NMMPI data in (Yong-Ze et al., 2017) and expands the data from 2014 to 2016 according to its method.

As for the remaining three types of data, they can be obtained from the *China Industrial Statistical Yearbook* series and *China industrial statistic yearbook* series, but the base period is set to 1990 according to the literature (Yong-Ze et al., 2017). According to the fixed asset investment price index of *China Statistical Yearbook* (2017), the output of NMMPI has been deflated. To remove the unit limit of the data, the zero-mean normalization method is used to convert the original data into a pure dimensionless value before regression.

Results and analysis

Although it is empirically known that the model has severe collinearity, the

collinearity is tested before using the Ridge regression. The collinearity can be detected by various methods, for example, 1) Pearson correlation test; 2) Variance inflation factors; 3) Eigenvalues of the correlation matrix of the independent variables, and 4) Pairwise scatter plots of pairs of independent variables. The first two methods are used in this paper, and the results of the Pearson and VIF tests are shown in the Table 1 and Table 2, respectively.

In the field of Statistical Science, the Pearson correlation coefficient is widely used to measure the degree of correlation between two variables X_1 and X_2, which was proposed by Carl Pearson and Francis Galton in the 1880s. The Pearson correlation coefficient varies from -1 to 1. Where, 1, 0, -1 represent positive correlation, irrelevant or no correlation and negative correlation, respectively.

We can also detect the multi-collinearity by the variance expansion factor (VIF). VIF refers to the ratio of the variance between the explanatory variables with and without multi-collinearity and it is the reciprocal of tolerance. The larger the VIF, the more severe the collinearity is. A rule of thumb is that there is no multi-collinearity when $0 < VIF < 10$; when $10 \leq VIF < 100$, there is strong multi-collinearity; and when $VIF \geq 100$, there is severe multi-collinearity. Selecting the coefficient λ is a process to solve a dilemma. A smaller λ value can guarantee a lower bias, but VIF will be relatively larger. On the contrary, a larger λ value will ensure a smaller VIF, but the deviation will increase. Our goal is to find the most appropriate λ value for the intended purpose.

Observing Table 1 and Table 2, the correlation coefficients are all above 0.82 in Table 1, and statistically significant at the 0.01 level. In Table 2, the VIF far exceeds the critical value of severe collinearity. Both cases indicate that there is severe collinearity in the model. This provides evidence for the use of the Ridge regression method.

According to the Ridge trace in Fig. 3 and the VIF diagram in Fig. 4, we choose λ=0.007 as the Ridge regression parameter. At this point, the coefficient is basically in a stable state (see Fig. 3, λ is denoted as k). The VIF values (see Fig.4) fall sharply at the initiation phase, and decrease gently as the λ becoming greater. When it comes to 0.007, the VIF values has entered to a suitable small level (<5), which illustrates that the method of Ridge regression effectively overcomes the problem of multi-collinearity. The regression results are shown in Table 3. Firstly, when λ=0.007 is selected as the Ridge regression parameter, the equation has an ideal goodness of fit, and its statistic (**Adj. R-Square**) reaches 0.99; Secondly, the estimated coefficients of the explanatory variables are all positive (**see B),** which is in line with the economic sense of the NMMPI industry, and the statistical test results of the coefficients are significant (see Table 3). In short, the estimation results are reasonable and satisfy the expected objectives, and the model equation can be rewritten as:

$$\begin{aligned}\ln Y_t = {} & -7.59448765 - 0.25387248 \ln X_{1t} + 0.57220183 \ln X_{2t} - 0.28931539 \ln X_{3t} \\ & + 0.01510996 (\ln X_{1t})^2 + 0.04593982 (\ln X_{2t})^2 - 0.01452651 (\ln X_{3t})^2 \\ & - 0.02671263 \ln X_{1t} \ln X_{2t} + 0.01595996 \ln X_{1t} \ln X_{3t} - 0.02856042 \ln X_{2t} \ln X_{3t} \end{aligned} \quad (9)$$

With the estimated coefficients, the output elasticity of the input factors can be calculated according to the (2), (3) and (4). Then, according to the estimated coefficients and computed output elasticities, the elasticity of substitution between the

input factors can be obtained according to (5), (6) and (7). The results are shown in Table 4.

It can be seen from the Table 4. that during the sample period, the output elasticities of all input factors are positive and they have gentle upward trends, indicating that with the growth and development of China's economy and technology, the productivity of China's NMMPI has been continuously improved. Among the output elasticities of the three factors, only the output elasticities of labor are greater than 1($\eta_L > 1$), indicating that the output is growing faster than factors input. At this time, increasing the amount of labor input, the average output will increase. The output elasticity of capital and energy are less than 1($\eta_K, \eta_E < 1$), indicating that the output is growing less than factors input. At this time, increasing the input of capital and energy, the average output will decrease. However, the average of the output elasticity of the three factors is greater than 1($\bar{\eta} > 1$), and there is also a rising trend, indicating China's NMMPI is still in the stage of progressively increasing with respect to returns to scale. This result is also consistent with several literatures that studied the output elasticities in other industries, such as (Lin & Jr, 2013; Shi, 2010; Xie et al., 2015), but they did not consider the average output elasticity.

Turn to the substitution elasticities of the three input factors over sample time showed in Table 4. First, as discussed in the third part of this paper, the conclusions of the elasticity of substitution in the world are still unclear. In theory, input factors can be complementary or substitutable (Ma et al., 2009). However, because of differences in economic development levels, industrialization levels, and even different region, the relationship between factors is significantly different. Taking the relationship between energy and capital as an example, some scholars have concluded that they are substitutes, while others have complementary results. Even with the same substitute relationship, the degree of substitution varies significantly from industry to region. (Griffin & Gregory, 1976; Ma, Oxley, Gibson, & Kim, 2008) argued that China's energy and capital substitution elasticity was between 0.6-0.8, while (Zhaoning & Deshun, 2004) proved it to be higher than 2.5, and (Zheng & Liu, 2004b) clarified that China's energy and capital substitutions are highly uncertain. From a global point of view, the substitution elasticity between energy and capital of Greece, Portugal, and South Korea is 0.97, 0.89, and 0.79, respectively (Cho, Nam, & Pagán, 2004; Christopoulos & Tsionas, 2002; Vega-Cervera & Medina, 2000). The results of this paper show that during the sample period, the relationship between energy and capital in China's NMMPI is substituted, and the substitution elasticity is around 1.01.

Implications and recommendations

Currently China is facing immense environmental pressures, and factor substitution is an effective way to achieve energy conservation and emission reduction targets. Given China's vast territory and varying levels of economic development, scholars are increasingly focusing on the issue of factor substitution more effectively from a

regional or industry perspective. This paper takes the NMMPI in China as a perspective and studies the factor substitution problem by establishing a translog function model. Through analysis, we found that, during the sample period, there is a good substitution relationship between the input factors of NMMPI of China. Both labor and capital can replace energy to a certain extent, which suggests that we can achieve energy substitution through measures such as relaxing energy price controls, raising labor wages, and increasing capital investment and so on. That the elasticity of substitution for energy and labor is higher than that for energy and capital ($\sigma_{LE} > \sigma_{KE}$) and the output elasticity of labor is the highest among three factors ($\eta_L > \eta_K, \eta_E$) should be considered in policy design because the relatively abundant of labor of China. Although capital's alternative to energy is a little less than labor's alternative to energy($\sigma_{KE} < \sigma_{LE}$), capital's replacement of energy should also be fully utilized, given China's current abundant funds and insufficient investment.

Taking the cement industry in the NMMPI as an example, China has not only overcapacity but also a significant proportion of low-end cement. There are still quite a few pre-calciners in China that still have high energy consumption and heavy environmental load. Compared with developed countries such as Japan, France, and Denmark, there are considerable gaps in resource utilization and technology levels. The problems caused by excessive and rapid development in the past 10 years have been fully revealed, which has become the status quo of China's NMMPI. Based on this, the Chinese government should start from the following aspects to improve the status quo of the NMMPI. First, we should actively guide NMMPI enterprises from energy-intensive to technology-oriented, capital-intensive, and from small-scale woolen growth to large-scale. It could be realized through factor substitution. The second is to accelerate the pace of reform of the supply side structure of NMMPI, impose strict access to the market, and eliminate backward production capacity. From the aspects of institutional setup, human resource allocation, R&D investment, and intellectual property protection, the government should strive to improve the investment capacity of large and medium-sized enterprises, improve the resource utilization rate of large and medium-sized enterprises in China's NMMPI, and transform the development mode. The main purpose of this is to take advantage of the current high output elasticities of labor and capital. Finally, since China's large and medium-sized enterprises are mostly state-owned enterprises, enterprises should also make full use of the favorable environment of internationalization, globalization, and integration of the world economy, actively introduce advanced technologies from developed countries, increase productivity, and help the government to achieve its established strategy. These measures could be applied to the entire NMMPI of China.

Conclusions

In this paper, the translog production function model, which was widely used by scholars, was employed to study the elasticity of substitution between the three

production factors of capital, labor, and energy in China's NMMPI, which has filled the gap in the literature of inter factor substitution for specific industries. Ridge regression is used to solve the problem of severe collinearity of the model. As a typical representative of China's high energy consumption, high emission, and low-efficiency industries, NMMPI is a pillar to China's industrialization and urbanization. As a regular industry with high growth and profit accumulation capacity, China's NMMPI should make outstanding contributions to China's strategic goals such as energy conservation and emission reduction, the shift of development mode, and green development. According to the results and analysis above, several conclusions are summarized as follows:

1) During the sample period, the output elasticities of the three input factors of capital, labor, and energy in China's NMMPI are positive. The output elasticity of labor(η_L) is 1.594~1.699, and that of energy(η_E) and capital(η_K) are 0.855~0.921 and 0.795~0.864, respectively. In general, they showed a relatively gradual growth trend indicating the improving of the utilization efficiency of input factors in NMMPI of China. In comparison, the output elasticity of capital is relatively low, which is closely related to the backwardness of equipment in the NMMPI of China.

2) During the sample period, the elasticities of substitution of the three input factors of capital, labor, and energy in China's NMMPI are positive. The substitution elasticity of energy-labor (σ_{KL}) is 1.021~1.023, and that of labor-energy (σ_{LE}) and capital-energy (σ_{KE}) are 1.018~1.019 and 1.017~1.019, respectively. During the sample period, the substitution elasticity has a downward trend, but at the end of the sample period, the downward trend tends to be stable and has a growth trend.

3) China's NMMPI industry is still in the stage of increasing returns to scale, and growing investment would accelerate output. China's NMMPI has good substitution relationship between input factors of capital, labor, and energy. Through relevant policies and institutional design arrangements, China stimulates and increases the input of capital and labor factors, restrains and reduces the contribution of energy factors, realizes the re-allocation of input factors, and realizes the strategic goal of energy conservation, emission reduction, and development mode transformation.

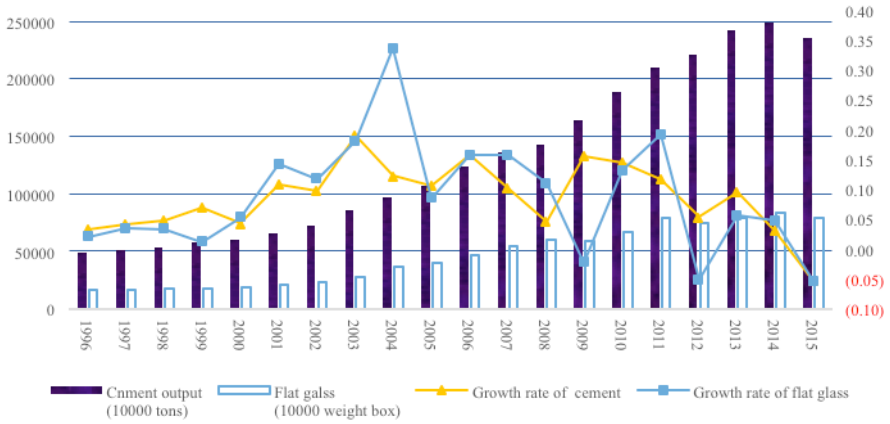


Fig. 1. The output of cement and plate glass in China's NMMPI during 1996-2015

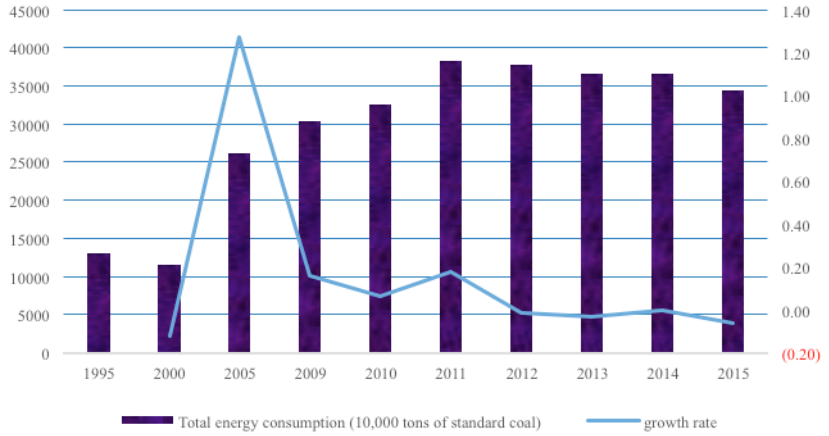


Fig. 2. The total energy consumption of NMMPI and growth rate during 1995-2015

Table 1. Pearson Correlation analysis

		K	L	E
K	Pearson	1	.981**	.840**
	Sig (2-tailed)		.000	.000
	N	17	17	17
L	Pearson	.981**	1	.829**
	Sig (2-tailed)	.000		.000
	N	17	17	17
E	Pearson	.840**	.829**	1
	Sig (2-tailed)	.000	.000	
	N	17	17	17

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2. The VIFs of all explanatory variables.

Variable	VIF	1/VIF
ln K	3717949.9	0.0000003
ln L	4551302.7	0.0000002
ln E	316426.0	0.0000032
ln K ln L	19274061.7	0.0000001
ln K ln E	765326.6	0.0000013
ln L ln E	1093068.2	0.0000009
ln K ln K	1932628.9	0.0000005
ln L ln L	11612977.5	0.0000001
ln E ln E	156117.0	0.0000064
Mean VIF	4824428.0	

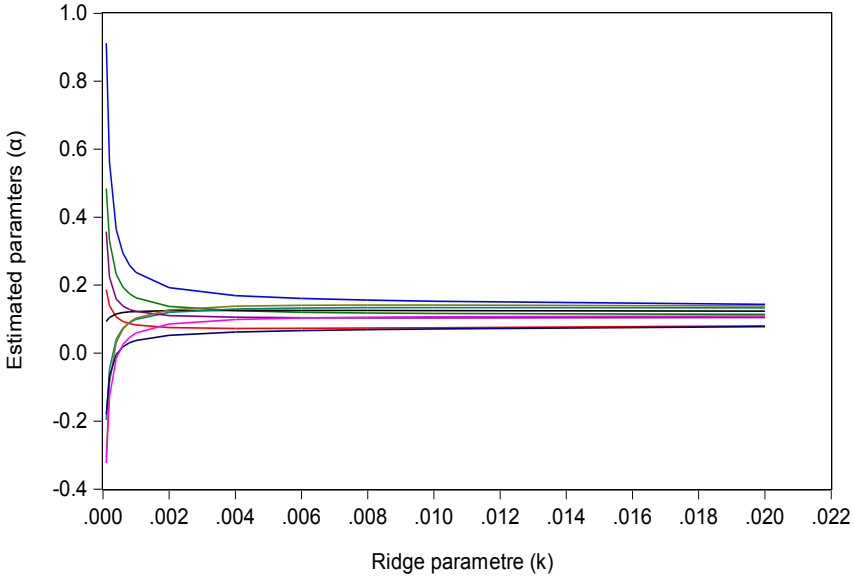


Fig. 3. Ridge trace of the coefficients of the Ridge regression

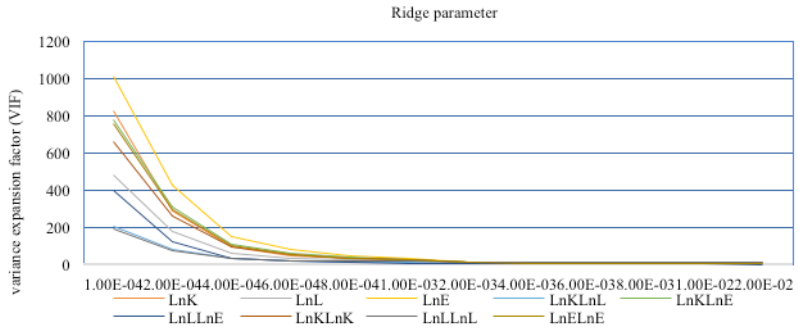


Fig. 4. The VIFs of the variables of the Ridge regression

Table 3 Model result of Ridge regression

Ridge Regression with λ = 0.007					
Mult.R			0.9977374370		
R-Square			0.9954799933		
Adj. R-Square			0.9896685561		
Standard Error (SE)			0.1045302299		
ANOVA Table					
	DF	**SS**	**MS**		
Regress	9.000	16.845	1.872		
Residual	7.000	0.076	0.011		
***F* value**		**Sig. *F***			
171.2966958		0.0000002			
Variables in the Equation					
	B	**SE(B)**	**Beta**	**B/SE(B)**	**Sig.**
LnK	0.25387248	0.03747404	0.13346173	6.77462341	0.00025912
LnL	0.57220483	0.17258862	0.08694789	3.31542629	0.01284544
LnE	0.28931539	0.04680642	0.11178325	6.18110511	0.00045353
LnKLnL	0.02671263	0.00252055	0.12001297	10.59794553	0.00001457
LnKLnE	0.01595996	0.00162699	0.13013288	9.80952661	0.00002428
LnLLnE	0.02856042	0.00335852	0.10681480	8.50388255	0.00006159
LnKLnK	0.01510996	0.00251090	0.13231770	6.01775060	0.00053275
LnLLnL	0.04593982	0.01375235	0.08617302	3.34050730	0.01241104
LnELnE	0.01452651	0.00228679	0.11193671	6.35237157	0.00038436
Constant	-7.59448765	1.10138624	0.00000000	-6.89539000	0.00023229

Table 4. Output elasticity and elasticity of substitution of factors input in NMMPI.

Year	α_K	α_L	α_E	$\bar{\alpha}$	σ_{KL}	σ_{KE}	σ_{LE}	$\bar{\sigma}$
2000	0.79506	1.59655	0.85497	1.082194	1.022669	1.018682	1.019264	1.020205
2001	0.79451	1.59444	0.85609	1.081168	1.022691	1.018679	1.019267	1.020212
2002	0.79583	1.59587	0.85809	1.083265	1.022659	1.018642	1.019237	1.020179
2003	0.80194	1.60624	0.86672	1.091636	1.022493	1.018479	1.019079	1.020017
2004	0.81184	1.62232	0.87849	1.104216	1.022233	1.018240	1.018857	1.019777
2005	0.81534	1.62761	0.88291	1.108622	1.022145	1.018155	1.018780	1.019693
2006	0.81859	1.63227	0.88557	1.112141	1.022065	1.018089	1.018724	1.019626
2007	0.82358	1.64111	0.89035	1.118345	1.021935	1.017982	1.018621	1.019513
2008	0.83354	1.65782	0.89806	1.129806	1.021684	1.017790	1.018443	1.019305
2009	0.83796	1.66318	0.90079	1.133978	1.021585	1.017711	1.018384	1.019227

201	0.84	1.67	0.90	1.14	1.02	1.01	1.01	1.01
0	614	598	743	3185	1390	7555	8243	9063
201	0.85	1.67	0.91	1.14	1.02	1.01	1.01	1.01
1	094	903	258	7514	1302	7454	8179	8978
201	0.85	1.68	0.91	1.15	1.02	1.01	1.01	1.01
2	463	324	451	0793	1224	7395	8136	8918
201	0.85	1.69	0.91	1.15	1.02	1.01	1.01	1.01
3	981	270	770	6736	1097	7308	8049	8818
201	0.86	1.69	0.92	1.16	1.02	1.01	1.01	1.01
4	394	949	056	1328	1002	7236	7983	874
201	0.86	1.69	0.91	1.16	1.02	1.01	1.01	1.01
5	365	776	906	0158	1015	7252	8006	8758
201	0.86	1.69	0.91	1.15	1.02	1.01	1.01	1.01
6	380	571	782	911	1024	7261	8030	8772
Me	0.83	1.65	0.89	1.12	1.02	1.01	1.01	1.01
an	124	067	304	498	1777	7877	8546	9400

References

China Statistics Press. China Statistical Yearbook-2017. Beijing, China: China Statistics Press.

Chen, S., Chen, D., Economics, S. O., & University, F. (2018). Air Pollution,Government Regulations and High-quality Economic Development. *Economic Research Journal*.

Chen, W., Wu, Z., He, J., Gao, P., & Xu, S. (2007). Carbon emission control strategies for China: A comparative study with partial and general equilibrium versions of the China MARKAL model. *Energy, 32*(1), 59-72.

Cho, W. G., Nam, K., & Pagán, J. A. (2004). Economic growth and interfactor/interfuel substitution in Korea. *Energy Economics, 26*(1), 31-50.

Christopoulos, D. K., & Tsionas, E. G. (2002). Allocative inefficiency and the capital-energy controversy. *Energy Economics, 24*(4), 305-318.

Ding, Y., & Li, F. (2017). Examining the effects of urbanization and industrialization on carbon dioxide emission: Evidence from China's provincial regions. *Energy, 125*, 533-542.

Du, Gang, & Chuanwang. (2015). Sustainability, Vol. 7, Pages 7112-7136: Determinants of Electricity Demand in Nonmetallic Mineral Products Industry: Evidence from a Comparative Study of Japan and China.

Fan, Y., Liao, H., & Wei, Y. M. (2007). Can market oriented economic reforms contribute to energy efficiency improvement? Evidence from China. *Energy Policy, 35*(4), 2287-2295.

Feng, H., & Statistics, D. O. (2015). Formula Correction and Estimation Methods Comparison on Elasticity of Substitution within Translog Functions. *Journal of Quantitative & Technical Economics*.

Griffin, J. M., & Gregory, P. R. (1976). An Intercountry Translog Model of Energy Substitution Responses. *American Economic Review, 66*(5), 845-857.

Guo, W., & Wang, W. (2005). Analyzing five factors for the choke point of China's energy sources. *Journal of China University of Geosciences*.

Hu, H., & Kavan, P. (2014). Energy Consumption and Carbon Dioxide Emissions of China's Non-Metallic Mineral Products Industry: Present State, Prospects and Policy Analysis. *Sustainability, 6*(11), 8012-8028.

Li, J., & Sun, C. (2018). Towards a low carbon economy by removing fossil fuel subsidies? *China Economic Review, 50*, 17-33.

Lin, B., & Jr, P. K. W. (2013). Estimates of inter-fuel substitution possibilities in Chinese chemical industry. *Energy Economics, 40*(2), 560-568.

Lin, B., & Ouyang, X. (2014). Analysis of energy-related CO 2 (carbon dioxide) emissions and reduction potential in the Chinese non-metallic mineral products industry. *Energy, 68*(8), 688-697.

Ma, H., Oxley, L., & Gibson, J. (2009). Substitution possibilities and determinants of energy intensity for China. *Energy Policy, 37*(5), 1793-1804.

Ma, H., Oxley, L., Gibson, J., & Kim, B. (2008). China's energy economy: Technical change, factor demand and interfactor/interfuel substitution. *Energy Economics, 30*(5), 2167-2183.

Ouyang, X., & Lin, B. (2014). A projection of future electricity intensity and conservation potential in the Chinese building materials industry. *Energy & Buildings, 84*(84), 268-276.

Rogelj, J., Den, E. M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., . . . Meinshausen, M. (2016). Paris Agreement climate proposals need a boost to keep warming well below 2 °C. *Nature, 534*(7609), 631-639.

Shi, H. (2010). Substitution Elasticity Among Energy,Capital and Labor Inputs in Chinese Steel Sector——based on a trans-log production function. *Journal of Industrial Technological Economics*.

Smyth, R. (2011). Substitution between energy and classical factor inputs in the Chinese steel sector. *Applied Energy, 88*(1), 361-367.

T. Azomahou, T., Boucekkine, R., & Nguyen-Van, P. (2008). Promoting clean technologies: The energy market structure crucially matters. *Working Papers, 2008-032*(6), 697–711.

Vega-Cervera, J. A., & Medina, J. (2000). Energy as a productive input: The underlying technology for Portugal and Spain. *Energy, 25*(8), 757-775.

Xie, C., Hawkes, A. D., Lund, H., & Kaiser, M. J. (2015). Estimation of inter-fuel substitution possibilities in China's transport industry using ridge regression. *Energy, 88*, 260-267.

Yong-Ze, Y. U., Liu, F. J., & Zhang, S. H. (2017). China's Industrial Sector Capital Stock Measurement: 1985-2014. *Review of Industrial Economics*.

Zeng, N., Ding, Y., Pan, J., Wang, H., & Gregg, J. (2008). Climate Change: The Chinese Challenge. *Science, 319*(5864), 730-731.

Zhang, M., & Huang, X. J. (2012). Effects of industrial restructuring on carbon reduction: An analysis of Jiangsu Province, China. *Energy, 44*(1), 515-526.

Zhang, Y., & Ye, A. (2014). Directed Technical Change and Technology Selection in China——Empirical Study Based on the Analysis of Factor Substitution Elasticity. *Industrial Economics Research*.

Zhang, Y. L., & A-Zhong, Y. E. (2013). Regional Technology Selection and Matching Difference in Factor Structure in China from 1996 to 2010. *Journal of Finance & Economics*.

Zhaoning, Z., & Deshun, L. (2004). China's Trans-log Production Function Using Capital,Energy and Labor as Input. *Systems Engineering-theory & Practice, 24*(5), 51-54.

Zheng, Z. N., & Liu, D. S. (2004a). China's Trans-log Production Function Using Capital, Energy and Labor as Input. *Systems Engineering-theory & Practice*.

Zheng, Z. N., & Liu, D. S. (2004b). Uncertainty of Capital-energy Substitution in China. *Operations Research & Management Science*.

Research on Evolution Mechanism and Development Strategy of Rural Human Settlement Environment Based on Characteristics of China-Suzhong Water Network—— Taking Ping'an Community in Haimen City, Jiangsu Province as an Example

Huang Xiaoqing, Southeast University, China

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
The "frame-drainage-dike" water system in the rural areas of China's Suzhong is one of the achievements of the "Reclamation project" implemented by Zhang Jian in the early 20th century. On the one hand, the system has evolved into a unique geographical feature, which has important historical value. On the other hand, changes in lifestyles have impacted the human settlements in the aera and the living mode adjacent to water makes water governance a problem of rural human settlements that has to be faced. Through the research on the evolution process of human settlements in this area, the water environment problem is the result of the comprehensive action of multiple factors which are as follows: 1. Pollution - the amount of pollution exceeds the self-cleaning load; 2. Structure - the network interoperability brings inefficiency of water pollution discharge; 3. Spatial pattern--village settlement planning changes the traditional human settlement pattern; 4. Life pattern--the dependence on the water system is reducing; 5. Pollution Control--the essence of government pollution control means is "governance after pollution first". The water pollution formation mechanism reflects the running-in process between the human settlement environment and the water system in the area, and its essence is the gradual deviation and passive treatment plan. Finally, in order to make full use of resource endowment and develop this water network system, this paper proposes strategies from the following aspects-the water, village and government. From then on, it improves the rural water environment governance system that adapts to new era.

Key words: rural areas in central Jiangsu, water network system, human settlements environment, evolution mechanism, comprehensive role, development strategy

iafor
The International Academic Forum
www.iafor.org

1. Introduction

As is known to all, Jiangnan Waterfront has been the leading role in the writings of writers since ancient times. For example, " *一江烟水照晴岚，两岸人家接画檐，芰荷丛一段秋光淡* ";"*君到姑苏见，人家尽枕河。古宫闲地少，水巷小桥多*" ; "*黄鹂巷口莺欲语，乌鹊河头冰欲销。绿浪东西南北水，红栏三百九十桥*" .They all express the water-town temperament of thin water and long flow, smoke and rain lanes in southern Jiangsu. But the plain area in central Jiangsu is also a water-town. What are its characteristics, how to integrate with the local human settlements model, what kind of environmental problems are faced, and how to protect and develop it?

Through the texture maps of 2 km² in the rural areas of southern and central Jiangsu, we can clearly see the difference between them. If the texture of rural areas in Suzhou is regarded as "perceptual nature", then the rural areas of Nantong City are "rational planning". Different from the characteristics of natural flow water network in southern Jiangsu, the water network in central Jiangsu often presents grid-like layout with strong artificial characteristics, which breeds different texture characteristics and residential patterns in rural areas of central Jiangsu, and has far-reaching significance for protection and development. However, with the passage of time, the gradual deterioration of water environment has become an urgent rural environmental problem to be solved in the context of the new era, and has become the key to Rural Revitalization and vitality remodeling.

Fig. 1 Texture Map of Rural Areas in Suzhou City, Jiangsu Province
Source: Web search

Fig. 2 Texture Map of Rural Areas in Nantong City, Jiangsu Province
Source: Web search

Taking the Ping'an community in Ruibei Village, Haimen City, Jiangsu Province, as an example, this paper combs the evolution process of human settlements under the water network system, traces back to the source and explores the water environment governance problems in rural areas in central Jiangsu Province, which is an important basis for the ecological civilization era to deal with the rural water environment governance and protect regional characteristics.

2. Human Settlement Model under the "Frame-drainage-dike" Water Network Structure

2.1 The plan for the purpose of “cultivating land and making money, expanding the people and expanding the industry”

Before reclamation, the central Jiangsu region suffered from frequent land salinization and river and sea disasters. Since the founding of Dasheng Yarn Mill, Zhang Jian found that people in the coastal areas of central Jiangsu, especially Haimen, were still suffering from natural disasters and no land. In 1885, Zhang Jian organized Tonghai Group Training, planned reclamation; in 1900, he formally took action, surveyed and mapped, and set up Tonghai Reclamation and Animal Husbandry Company (Fig. 3). The purpose of Tonghai Reclamation and Animal Husbandry Company was clearly stated in the Statute of Share Collection of Tonghai Reclamation and Animal Husbandry Company: "One thing is to make the land produce wealth, Qi people expand their business; the other is to increase the income of the country, and to make profits from capital and wealth...". By 1911, a total of 120,000 mu of land had been reclaimed. In 1914, Zhang Jian asked the court to open up state-owned wasteland for reclamation.

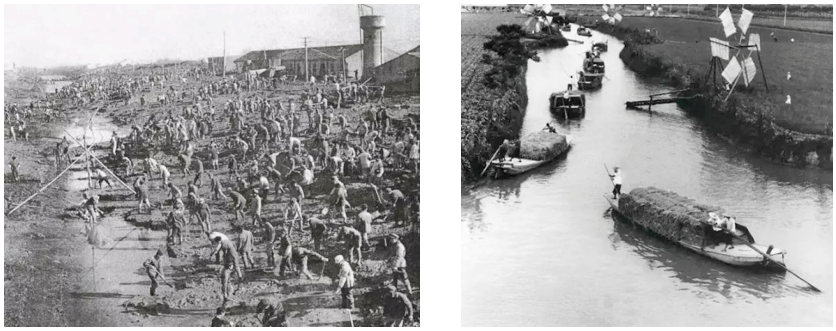


Fig.3 Reclamation Scene of Tonghai Project
Source: Web search

With the aim of “cultivating the land and making money, expanding the people and expanding the industry”, the plan is to lay the foundation for the establishment of the water network system in the Suzhong area. The water network system formed on this basis has changed the land salinization and the frequency of the rivers and seas in the coastal areas of the Soviet Union and China. The situation of the situation has formed a unique life pattern based on the water in the rural coastal areas .

2.2 The operation mechanism of water network guided by rationalism

The Tonghai Project shows that Zhang Jian is deeply influenced by pragmatic rationalism. When reclamation is carried out in this area, it first divides the area according to the local topographic and geomorphological characteristics, surveys and maps each area, and plans water conservancy according to local conditions; then it excavates the water system according to three levels, namely, the frame River (longitudinal), the drainage River (transverse), and the dike ditch (longitudinal), and sets up rivers in the backbone area between the area and the area, and the dike ditch on the south side of the central transverse road drains to it. A footbridge is built at both ends of each row of fields, crossing the Frame River to the main road. Unified grading standard for depth and width of gully and river, standard of straight grid of "#" type and chessboard type of road, and tillage and soil preparation (fig. 4).

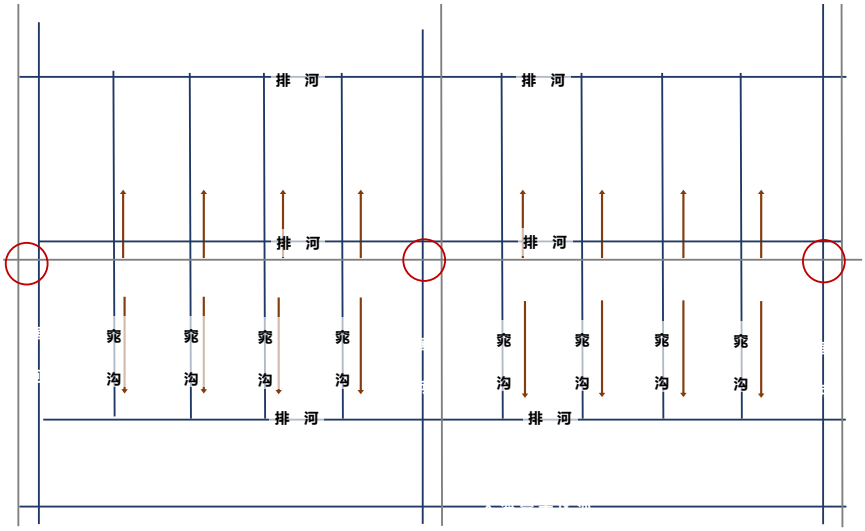


Fig.4 Water Network Model Diagram
Source: Self-drawn by the author

2.3 Historical Humanistic Value in the New Era Background

The formation of the water network system has gradually enabled the local people to have jobs and settlements, and the development of the "frame-drainage-dike" water network system has a history of more than a hundred years. On the basis of the water network, a unique water-based life pattern has gradually formed in the rural areas of the Central Jiangsu Plain. Under the background of the new era, the landform signs of the original countryside have important historical and humanistic value and are worthy of protection and development.

3. Characteristics of human settlement patterns in the study area

3.1 Typical Village in Central Jiangsu

Haimen City is located in the southeast of Jiangsu Province, south of the Yangtze River. Because a large amount of sediment deposited in the Yangtze River Estuary to form sand bars, the basic scale of township land began to be established during Qianlong period. However, due to frequent floods along the Yangtze River, land reclamation is difficult and the development of towns and villages is hindered. At the beginning of the 20th century, Zhangjian organized to reclaim farmland and water conservancy, and gradually formed the embryonic form of farmland network. Since then, the water network has been closely related to people's lives.

This paper takes Ruibei Village Ping'an Community in Haimen City as an example, and chooses a range of about 1 km *1 km to study (Fig. 5). The water system in the village is vertical and horizontal. Residences are arranged along both sides of the water system road, showing the typical spatial form of village in central Jiangsu Province.

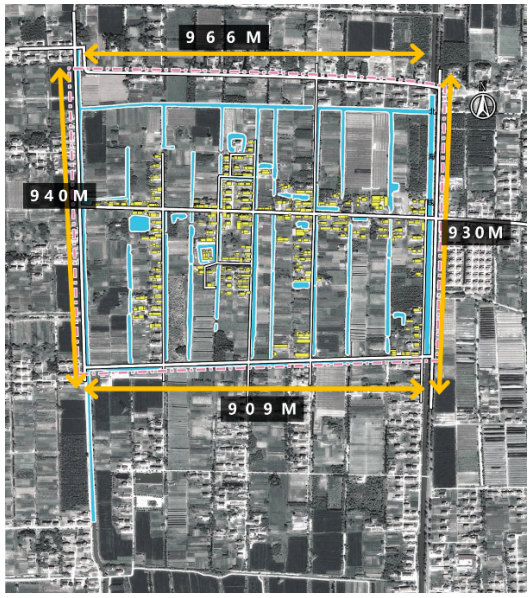


Fig. 5 Scope of study
Source: Self-drawn by the author

3.2 "Interlaced" Water system

In the research range of about 1km2, it includes the frame river at both ends of the east and west sections, with a width of about 2 meters and a distance of about 950 meters. The rivers at the north and south ends are about 1 meter wide and about 960 meters apart. The north-south gully has an average width of about 0.7-0.8 m and an average interval of about 12-15 m. Some local residents have self-extension water ponds, and their water nets basically have a grid layout and criss-crossing characteristics.

After the overall planning of the village in 1985, the main road of the east-west village was built, crossing the two sides of the frame river, cutting off the central gully, and the end between the local gully and the frame river was filled, showing the state of the broken river.

After calculation, the water network density in the study area is about 8.8km/km², the water network layout is regular, the level is clear, and the mesh is intercommunicated. However, the problem of sulcus breakage is prominent (Fig. 6).

Fig. 6 An aerial photograph of the current situation of Ping'an community
Source: Photographed by the author

3.3 "Blue-green Mosaic" in Paddy Field

The study found that the farmland of the Ping'an Community in Ruibei Village was naturally divided by the water system, and the soil was localized and presented in a strip-like layout pattern. The layout was basically characterized by “the residential area is on both sides of the road and the farmland is at the ends” (Fig. 7). That is, the dwellings are concentrated on both sides of the main road in the central part of the country, and the farmland is concentrated in the development state of the north and south ends.

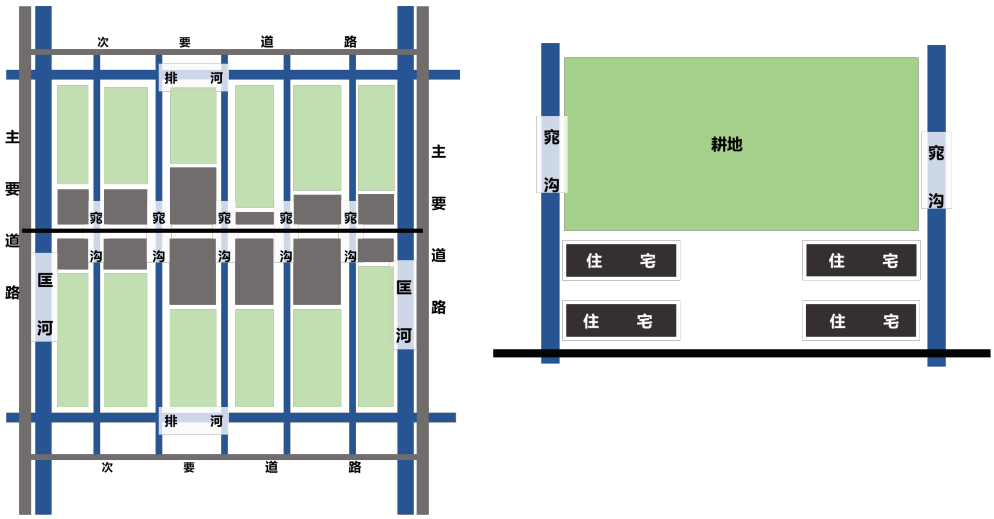


Fig.7 Layout pattern of farmland-dwelling-water system
Source: Self-drawn by the author

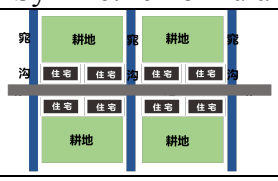
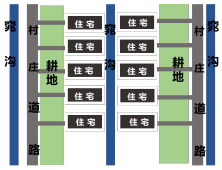
3.4 "Build by the Waterfront" of Residential Buildings

In the past typical research on the layout of rural areas in central Jiangsu, it was summarized as "high density strip type of coastal reclamation area". That is, the residential buildings located on both sides of rivers or roads show strip settlement distribution, or the rural space texture of "checkerboard grid" and so on.

On this basis, the author summarizes and refines it (Table 1). Firstly, according to the relationship between water system and road, it can be divided into two categories: parallel waterway and cross waterway. In parallel waterway, most of the dwellings are arranged along the canyon, while in cross waterway, most of the dwellings are arranged along the road and can be subdivided into arable land. - The "symmetry" of housing-road-residential-cultivated land and the "block" of housing-road-cultivated land.

Table 1 Classification Table of Residential Layout Patterns
Source: Self-drawn by the author

Relationship between water and roads	Crossing Water and Road: Arrangement of Residential Buildings along the Road	Water is parallel to road
Distribution of Residential Buildings	Arrangement along the road	Arrangement along the dike

Satellite Map			
Layout pattern	Symmetric Formula	Strip type	
			

The residential districts of Ping'an community show the characteristics of "building by water", which belongs to the "symmetrical" type of "crossing of waterways". The main roads of villages are vertical dikes, and the residential districts are mostly determinant layout. The overall layout of the residential districts shows scattered strips concentrated on both sides of the road. The inbound traffic connecting the main roads of villages in Ping'an community is built between the water system and the residential districts, separating the water system from the residents. The public space on one side of the river system is distributed in a narrow strip.

3.5 Difficulties in the management of sewage environment

With the continuous change of rural life mode, water environment problems become more and more prominent. Eutrophication of water body, waste dump by riverside, and direct drainage of rural domestic sewage, taking Ping'an community as an example, have become the water environment problems that plague the rural areas of the Central Jiangsu Plain (fig. 9). They have also become an important reason for the gradual alienation of local residential activities from water. In the face of "crisscrossing water systems" and "blue-green paddy fields". In the peaceful community of mosaic and residential buildings built by water, the deterioration of water environment and the living mode of water adjacent make water treatment become the problem of rural human settlements environment that we have to face.

4. Evolution Mechanism of Habitat Environment in Ping'an Community under the Characteristics of Water Network

4.1 Pollution - Pollution discharge exceeds self-net load of water system

The increase of pollution is the direct cause of the evolution of human settlements under the characteristics of the water network. In the early stage of water network formation, the rural ecological environment was good, the pollution discharge was less, and the water system could achieve self-purification. Since the 1960s, with the increase of pesticide and fertilizer consumption, the increase of industrial wastewater in the Yangtze Estuary and the continuous phenomenon that rural wastes and sewage were discharged directly into rivers without treatment, the discharge of rural pollution exceeded the negative effect of water self-purification. Lotus, leading to the gradual deterioration of the water environment.

In 2011, Nanjing promulgated relevant policies, the main rivers began to clean up water, but the water quality of dike ditch, which accounts for a large proportion of the

village, has not been improved.

Nowadays, there are four main pollution sources in Ping'an community, including industrial pollution, living pollution, agricultural pollution and aquaculture pollution. In the report, life pollution accounts for 50% of the total pollution, including domestic waste (plastic film, plastic foam, etc.) and domestic wastewater (organic matter, pathogens, eggs, etc.) entering the drainage system through direct drainage.

4.2 Water network structure-network interchange brings low effluent discharge efficiency

The study found that the flow velocity of the water system in Ping'an community is low and almost zero. There are two reasons for this. First, the central Jiangsu area is flat, the water network belongs to the plain tidal river network, which forms the flow power through the upstream fluctuating tide. When the tide rises, the flow of frame river gains power through the upstream and then flows into the Drainage River and then into the canyon. The water speed is low. Secondly, the water network of "frame-drainage-canyon" structure has many intersecting joints because of its network interconnection, which further reduces the internal flow speed. In the case of high tide, the flow of Kuanghe River is from south to north, and the direction of flow into drainage and gully is uncertain (Fig. 8-9).

Moreover, the main road of the village built in 1985, which runs through the East and west, separates the North-South trench into a broken-head river. At this time, the Kuanghe River flows into the Drainage River and then into the trench. The direction of the flow is fixed, the direction of the Drainage River is uncertain, and the velocity of the internal flow is almost zero (Fig. 10). Through the author's field research and development, it is found that the pollution in the vicinity of the canal which is cut off by the main road in Ping'an community is particularly serious nowadays. Besides the phenomenon of domestic waste accumulation, there is also the drying up problem of the canal water system caused by long-term silt accumulation (Fig. 11).

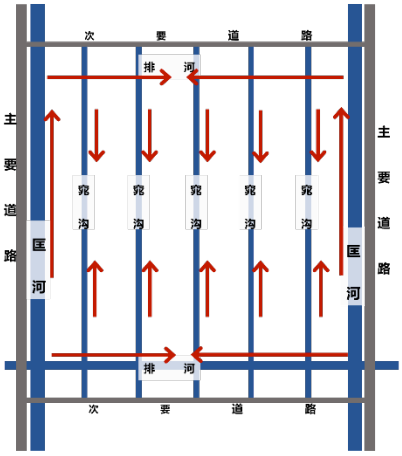


Fig. 8 Flow Direction before Main Road Construction (Taking Rising Tide as an Example)
Source: Self-drawn by the author

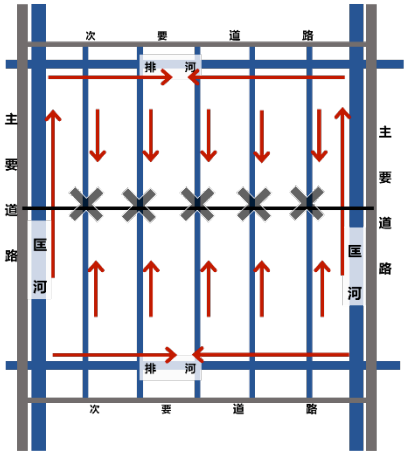


Fig. 9 Flow Direction after Main Road Construction (Taking Rising Tide as an Example)
Source: Self-drawn by the author

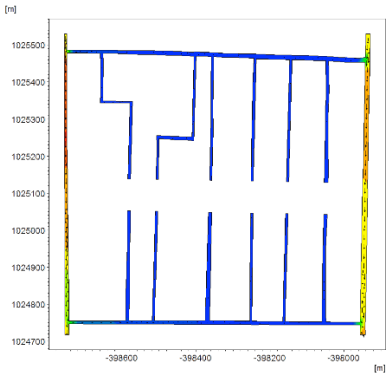


Fig.10 MIKE 11 software simulates water velocity
Source: Self-drawn by the author

Fig. 11 Status of pollution at the end of a dike
Source: Photographed by the author

4.3 Living Model: Decreased Dependence of Rural Living and Production on Water System

The change of life mode is directly reflected in the reduction of dependence on water system in rural production and life level, and the change of dependence on water system is also an important reason for the change of rural human settlements environment, mainly reflected in the change of rural life style, production mode and entertainment mode. First of all, in the agricultural era, the life style of living by rivers and drinking water has been changed. Now, with the popularization and development of tap water, the necessity of rivers for living has been replaced, and it is no longer an essential factor for survival. Secondly, in the aspect of production mode, the production of subsistence by farming is no longer cultivated because of the transfer of rural labor force to cities and the popularization of mechanized farming. Finally, in terms of entertainment mode, due to the rapid development of the modern information age, the entertainment mode of "water for pleasure" gradually disappeared, and the water bank as a rural public space was gradually replaced. On the one hand, the interaction between the changes of ecological environment on both sides of the water system and the changes of people's production and lifestyle, and the changes of production and lifestyle brought about water ring. The deterioration of the environment gradually leads to the combing of human settlements and water environment. On the other hand, with the completion of the new community center, rural residents advocate a preference for public open space with good hard pavement, in which the environment on both sides of the water system needs to be remedied.

4.4 Management System: The Overall Planning of Rural Residential Areas Reflects the Change of Human-Water Relation

The rural land system reform has brought about the transfer of rural living and production space, which has two main factors: passive system and active trend. Since Zhang Jian's implementation of reclamation and animal husbandry through the sea, the land management system in this area has undergone four stages of change. The first stage is the company tenancy system in late Qing Dynasty (1901). The head of household contracted land across the ditches and settled in scattered areas. The second stage is that after the implementation of land reform in 1949, the distribution of land among farmers gradually became average, basically one household, and initially formed a pattern of house-water-field. Residents settled in scattered areas of cultivated land with the ditches as the dividing line. Since the implementation of the household contract responsibility system in reform and opening-up, the rural

residential areas have been integrated, and the scattered residential layout has been integrated into a centralized determinant. Now with the large transfer of rural labor to cities, the cultivated land resources are gradually idle. Under the new era background, the trend of rural land cooperative scale operation has become more and more intense, and the government has re-integrated the existing land. Resources, centralized contracting and commissioned operation, belong to the active choice under the influence of the trend.

At the same time, the overall planning of rural settlements reflects the change of the relationship between people and water. In the early stage of the formation of water network, before the 1950s, the dwellings were semi-enclosed near the water, while new rural roads were built in the middle of communities, which formed the layout pattern of houses around the roads, farmland depending on both ends, the main roads of the countryside were separated from the ravines, and the direct connection between the dwellings and the water system was separated by inbound traffic. Therefore, the reform of land system and the overall rural planning have changed the production and living space and mode of traditional rural human settlements.

4.5 Pollution Control - The essence of government's pollution control means is "pollution first, then treatment"

From the point of view of water pollution control methods, rural sewage is directly discharged into the ditch, discharged into the Drainage River by the power of ebb tide, and finally into the frame river. However, the government's existing means of pollution control are often only to set up sewage treatment plants in the lower reaches of the frame river to treat rural sewage. Its essence is pollution first and then treatment.

In terms of internal river course cleaning, the government adopts physical methods to regularly clean up floating garbage in the river course. For the accumulated silt caused by rainstorm impact, the government first evaluates and classifies the quality of the canyon. For the canyon channel with better quality, the government will choose to dig out the silt and fill it in the canyon channel with poor quality, which results in the canyon. The length of the water system in the layer decreases, which impacts the structure of the water network.

5. Conclusion

The water pollution formation mechanism reflects the running-in process of the human settlement environment and the water system in the area, and its essence is the gradual deviation and passive treatment plan of the rural production and living mode and the water network system. The reduction of dependence on the water system in the countryside and the low ability to control have formed the problem that the peaceful community is “not adjacent to water but not water, but does not see water”. Therefore, in the context of the new era, facing the unique ecological and geographical features of the Soviet Union In the rural areas of China, the revitalization of water networks is not only related to restoring the ecological environment inside the village, but also has far-reaching significance for rural rejuvenation and vitality reshaping.

The water network in the rural areas of the Central Jiangsu Plain has distinct characteristics, which breeds a unique human settlements pattern, has profound epochal imprint and regional characteristics, records the development process of the region, and has far-reaching protection and development value. In order to protect and develop the water network system with distinct regional characteristics, the water network area in the Central Jiangsu Plain should make full use of its natural resources and bring into play the self-organizing benefits of rural space.
On the basis of these characteristics, this paper analyses the evolution mechanism of the local residential pattern, and finally puts forward some brief development countermeasures at the level of water network structure, villagers and government.
In the water network itself, it advocates opening source and activating network, improving the structure of water network, improving the operation efficiency of ecosystem, and forming a water network system of complex natural landscape and public activities. Through the planning and landscape design of linear rivers, the ecological riverside system adjacent to water is formed by connecting lines. At the same time, parks can be set up at the intersection of the main and secondary rivers as amplification nodes of the linear system of villages, carrying public activities of the whole rural community.

At the villagers' level, they advocate autonomy and sharing, improve the enthusiasm of improving the water environment in their hometown, take self-improvement and management as the goal, reduce spontaneously and break the water system.

Finally, the government needs to improve the rural sewage and rainwater diversion system, treat the sewage problem from the root, and guide the rural residents organically, in order to control the upstream industrial pollution emissions, add garbage collection stations in rural areas and other ways to reduce the emissions of pollution sources.

References

[1] Wu Liangyong, Zhangjian and Nantong, the first city in modern China [J]. *Urban Development, 2004 (12):* 16-19.

[2] Cai Weimin, Tang Huajun, Chen Youqi and Zhang Fenglong. Landscape pattern of rural settlements in typical areas of the Yellow River Delta in recent 20 years [J]. *Resource Science, 2004 (05):* 89-97.

[3] Yang Kaijian, Huang Yaozhi. Protection and Continuation of Rural Spatial Texture: Taking the Coastal Plain of Jiangsu Province as an Example [J]. *Jiangsu Urban Planning, 2011 (05):* 37-41.

[4] Zhou Guohua, He Yanhua, Tang Chengli, Qu Qiongying and Peng Peng. On the Study of Rural Settlement Model in the New Period [J]. *Progress in Geographic Science, 2010, 29 (02):* 186-192.

[5] Mei Yaolin, Duanwei, Wang Xiaochun. Spatial evolution analysis of rural settlements based on agricultural production mode --- Taking Nurturing Village of Changle Town, Haimen City as an example [J]. *Rural Planning and Construction, 2014 (01):* 106-114.

Contact email: 1012529641@qq.com

Optimized Approaches to Urban Spatial Form Design for Better Ventilation- A Study in Changzhou, China

Ding Jinming, Southeast University, China

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
Rapid urbanization process has brought about a global challenge in the ecological environment, such as air pollution and "Urban Heat Island Effect". On one side, climate is one of the most important elements that maintains human survival and production, and also the key factor of spatial morphology. On the other side, different spatial forms also affect local microclimate. Early in 1968, the WMO organized the first international urban climate conference to specially study the influences of urban planning and design that make on the climate. It is indispensable to seek for optimized approaches to urban spatial form design for better environment. Wind environment, a part of urban climate, plays a critical role in improving urban spatial environment. Strategies for better wind environment and constructions of urban ventilation corridor can effectively relieve air pollution and accumulated heat. Countries like Germany and Japan early studied macroscopic ventilation corridor planning, and combined it with urban master plan. Some urban spatial forms, such as density, height, volume rate, etc. have been further studied to seek for specific optimization. While most studies tend to get a qualitative control but have poor implementation. Quantitative studies are essential to be done. In this study, we will first make a simple introduction about the overall background wind environment in Changzhou. Then we will construct three-level ventilation corridors. Multi-dimension spatial morphology factors will be respectively extracted to simulate through CFD. Finally, several specific optimization approaches will be proposed for future urban design.

Keywords: urban ventilation, spatial morphology, CFD simulation, optimization

iafor
The International Academic Forum
www.iafor.org

1 Introduction

1.1 Background

China has begun a rapid urbanization process since the reform and opening. On one side, the fast-paced urbanization has brought about a huge improvement in infrastructure and economic growth. On the other side, it has also led to the explosion of urban population and the expansion of construction land. Furthermore, high-density and high-scale construction has intensified resource consumption and created unprecedented environmental pollution, which has become a global challenge and directly affected people's basic survival.

The problems associated with the urbanization process (but not limited to) mainly include air pollution, “Urban Heat Island Effect”, disease transmission etc. Firstly, according to the PM2.5 data released by foreign authorities, in China, every 1% of urbanization will increase the concentration of smog pollution by 0.029%. The health hazards caused by urban air pollution will directly lead to huge urban economic losses. Secondly, due to a large number of artificial heat, high regenerators such as buildings and roads, and reduced greening environment, the city has caused “high temperature”, which has many adverse effects on the urban space environment. Thirdly, the high concentration of population in the city and the close communication network have also created more favorable conditions for the spread of infectious and epidemic diseases.

Wind environment, a part of urban climate, plays a critical role in improving urban spatial environment. Strategies for better wind environment and constructions of urban ventilation corridor can effectively relieve air pollution and accumulated heat, and also help reduce the transmission efficiency of airborne diseases and the risk of infectious diseases. Early in 1968, the WMO organized the first international urban climate conference to specially study the influences of urban planning and design that make on the climate. On one side, climate is one of the most important elements that maintains human survival and production, and also the key factor of spatial morphology. On the other side, different spatial forms also affect local microclimate. It is indispensable to seek for optimized approaches to urban spatial form design for better environment.

1.2 Literature review

The theoretical research on urban wind environment involves many disciplines such as meteorology, environmental science, urban climatology, urban and rural planning etc. This paper mainly summarizes the research on wind environment in urban planning and related fields, including the construction of urban ventilation corridor, wind environment impact factors and improvement strategies, and related research on spatial morphology.

The Germany first constructed urban ventilation corridors in response to urban climate deterioration in the Ruhr area. The urban environmental climate map is used to carry out related research on the application of climate spatial planning (Ren et al.,2014). Related researches in China is still in its infancy. As early as in Hong Kong (Chinese University of Hong Kong,2013), in response to the deterioration of space environment in high-density areas, the wind speed ratio is used to assess the impact of buildings on the surrounding environment, and added guidelines on air circulation

intentions in the urban design guidelines. Zhu, et al. (2008) have proposed the operation mode of ventilation corridor. Germano M （2007） used parametric analysis method to evaluate the natural ventilation capacity of Basel, and drew the urban ventilation potential level map. Based on RS and GIS technology, Zhan et al. (2015) comprehensively analyzed the characteristics of regional wind environment, found out the urban air inlet, and excavated the existing ventilation corridor. Although some practical techniques, such as wind tunnel experiments and computer numerical simulations, have been applied to the research, most studies paid more attention to theoretical researches, which are out of touch with the practice.

The ventilation environment of the city's macro, meso and micro scales corresponds to different influencing factors. Zeng et al. (2016) analyzed different influencing factors from the overall urban form, urban structure, urban functional area and several dimensions of different climate zones, and proposed corresponding planning strategies. Based on the improvement of urban microclimate, Ding et al. (2012) proposed relevant indicators for urban texture optimization and urban street space optimization. The influence factors of the wind environment are complex. Scholars have generally constructed a research framework from macro to micro. However, most improvement strategies are stuck in the qualitative analysis, and the operational implementation of urban planning is insufficient.

When it comes to the researches on spatial morphology, more studies concerned about the optimization of urban macroscopic form or microscopic architectural form, while had less discussion on the city districts and blocks. Furthermore, most studies tend to be more qualitive rather than quantitative, and have poor implementation in practice. The universal approaches have not been summarized specifically, and a theoretical framework has not been built completely.

In this study, we will first make a simple introduction about the overall background wind environment in Changzhou in Section 2, in order to achieve several important parameters for later simulation. Then in Section 3, we will construct three-level ventilation corridors to get the optimal ventilation plan. In Section 4, several multi-dimension spatial morphology factors, concerning urban districts, core areas of heat island and blocks, will be respectively extracted to simulate through CFD. Finally, Section 5 will propose several specific optimization approaches for future urban design.

2 Current Situation

2.1 Thermal environment analysis

2.1.1 Average temperature

Some related climate data of Changzhou have been grabbed from the weather website. First is about the average temperature. Changzhou has four distinct seasons, and the average temperature in summer is relatively stable (Figure 1), while the overall temperature in Changzhou has a small increase year by year (Figure 2).

Figure 1: Monthly maximum/minimum temperature during 2014-2018.

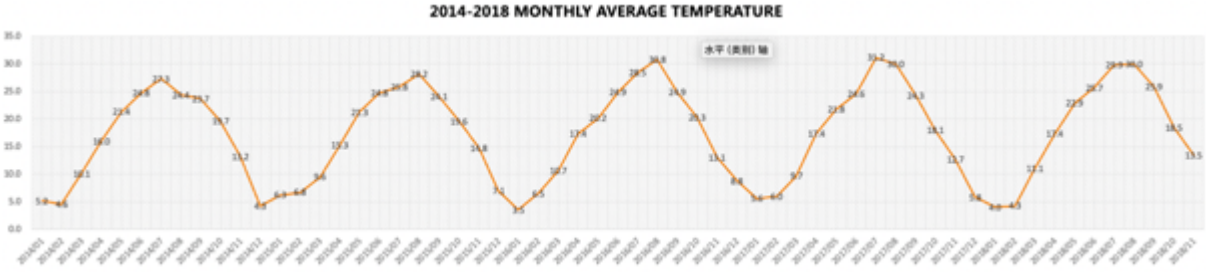


Figure 2: Monthly average temperature during 2014-2018.

2.1.2 Heat island effect

We also grabbed MODIS satellite data to get the thermal environment distribution map of Changzhou over the years (Figure 3). Through these pictures we can see that the heat island effect in the central city is obvious.

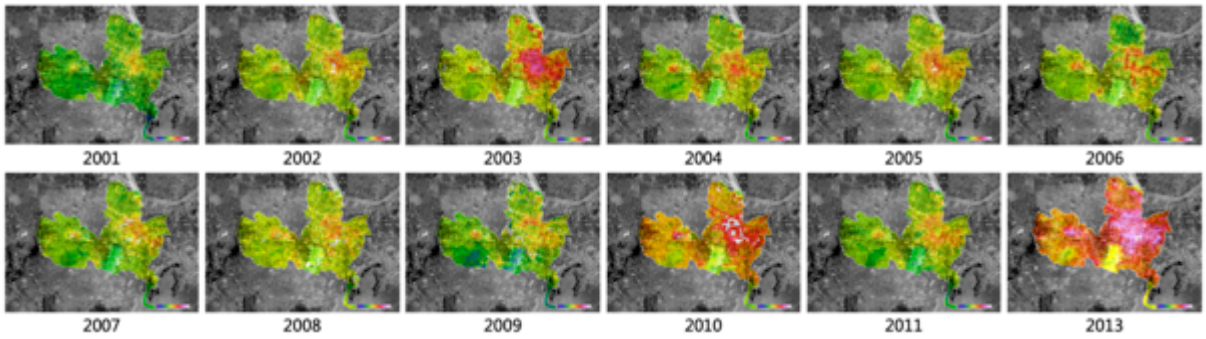


Figure 3: Thermal environment distribution maps of Changzhou.

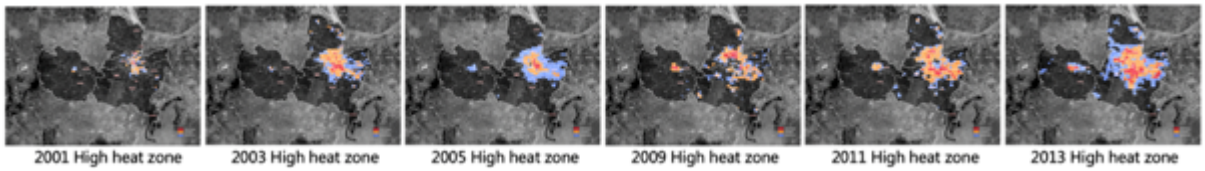


Figure 4: Areas with high heat.

Based on the thermal environment data, the areas with highest heat and higher heat were extracted to further analyze the core planning areas with the most severe heat island effect. (Figure 4) Then we superimpose these distribution maps to obtain the most severe areas in Changzhou. And these areas are the most important objects to

analyze and design in later planning. At the same time, we found some villages and towns around the city have also become hot, which are distributed in scattered around the city, and needed to be controlled in the planning to avoid environmental degradation. Last but not least, it is also worth analyzing that in the urban heat island center, there are also some relatively good areas, which should be further studied to get some successful experience for later design.

2.2 Wind environment analysis

2.2.1 Dominant wind direction

Changzhou is located in the climatic zone transitioning from the north subtropical zone to the warm temperate zone. Related wind environment data have been sort out to get the dominant wind direction and average wind speed. In the summer, the dominant wind is east-southeast (ESE), and in the winter is north-northeast (NNE). (Figure 5)

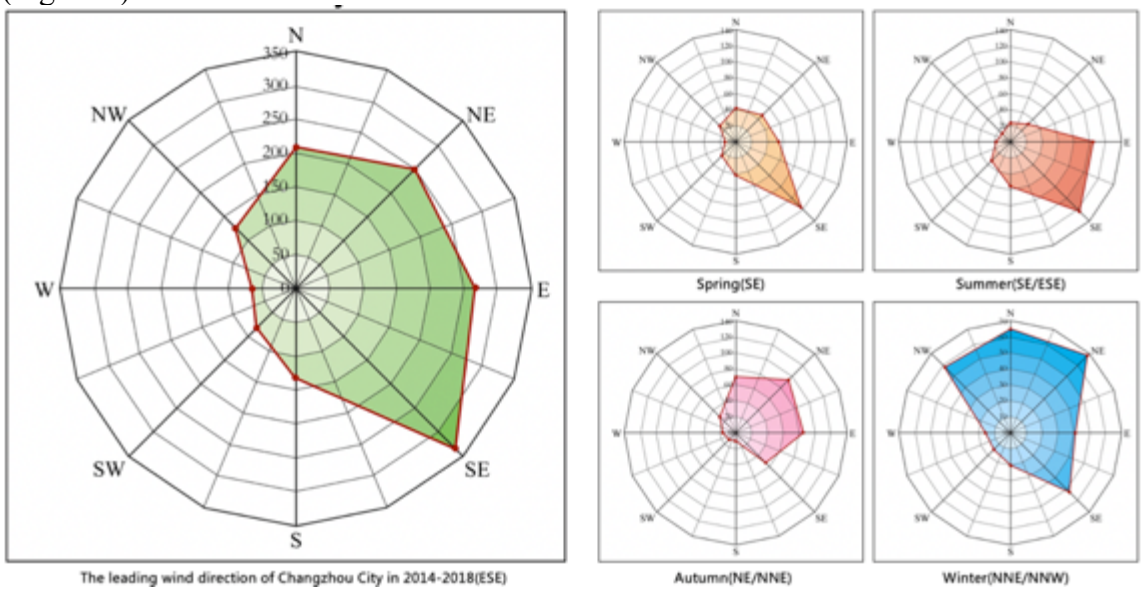


Figure 5: Dominant wind direction.

2.2.2 Average wind speed

According to the data, we can calculate the average annual wind speed is level 3-4, which is mainly 5.5 meters per second. (Figure 6)

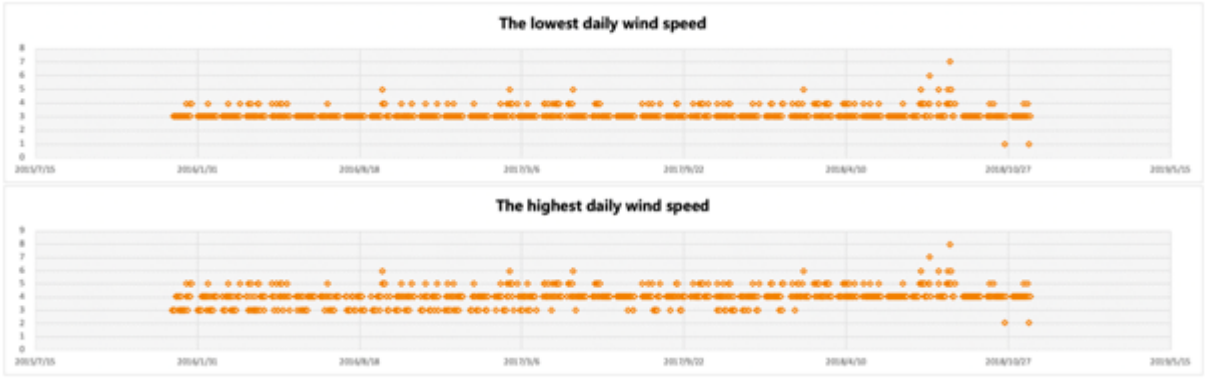


Figure 6: The lowest/highest daily wind speed.

2.2.3 Relationship between air pollution and wind

We further studied the relationship among air pollution, wind speed and wind direction. According to the data, the overall air quality in Changzhou is good. The air quality is good in summer, the second is in autumn, and the worst in winter. (Figure 7)

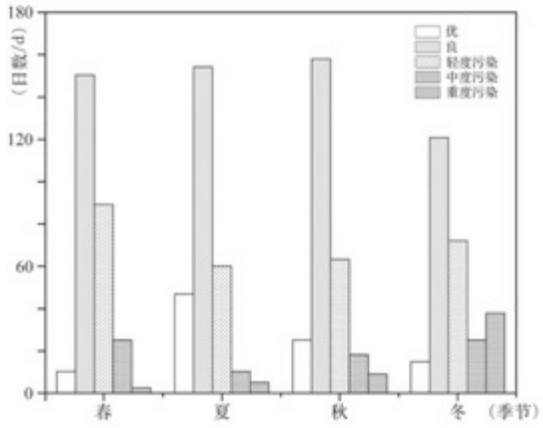


Figure 7: Distribution of daily air quality grades in Changzhou.

Through cross-analysis, it can be seen that the wind speed has obvious effects on the diffusion of pollutants: the higher the wind speed, the faster the pollution disperses. (Figure 8) In addition, the dominant wind to the southeast brings clean air at sea, which is conducive to dispersing pollution. While when the air reaches heavy pollution, the northwest wind component increases, indicating that the pollutant transport in the upstream area has a greater impact on the air quality of Changzhou. (Figure 9)

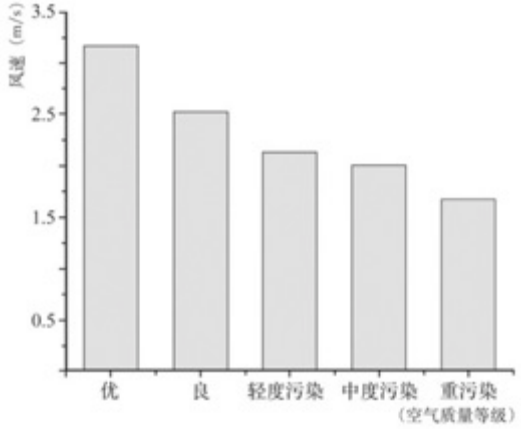


Figure 8: Average wind speed of various air quality levels.

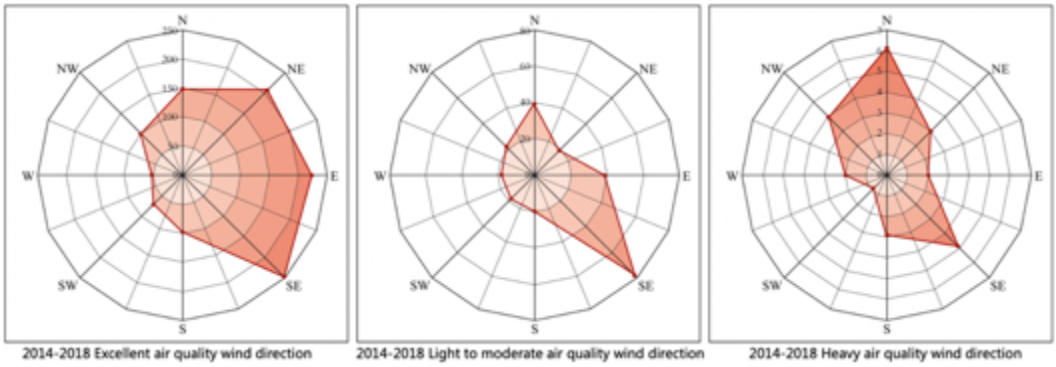


Figure 9: Wind direction with different air quality.

2.3 Wind environment simulation

Based on the basic spatial data and specific parameters that have been summarized above, we conducted the wind environment simulation through CFD. (Figure 10) According to the simulation results, the most prominent areas with poor ventilation are extracted, and the static and stable wind areas are delineated. Finally, the areas with the most severe wind and heat environment are superimposed, and the most comprehensive and prominent areas are selected as the space foundation and focus of the construction of the ventilation corridor. (Figure 11)

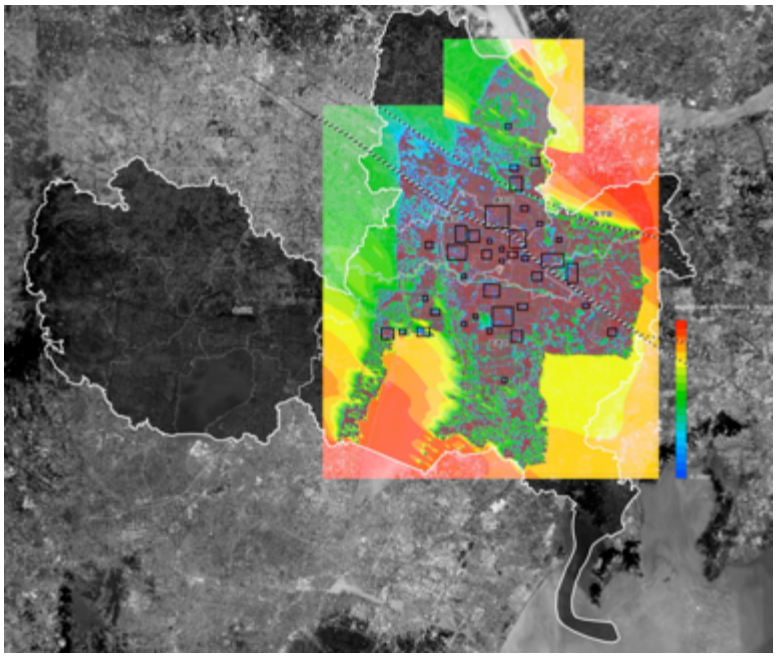


Figure 10: Wind environment simulation through CFD.

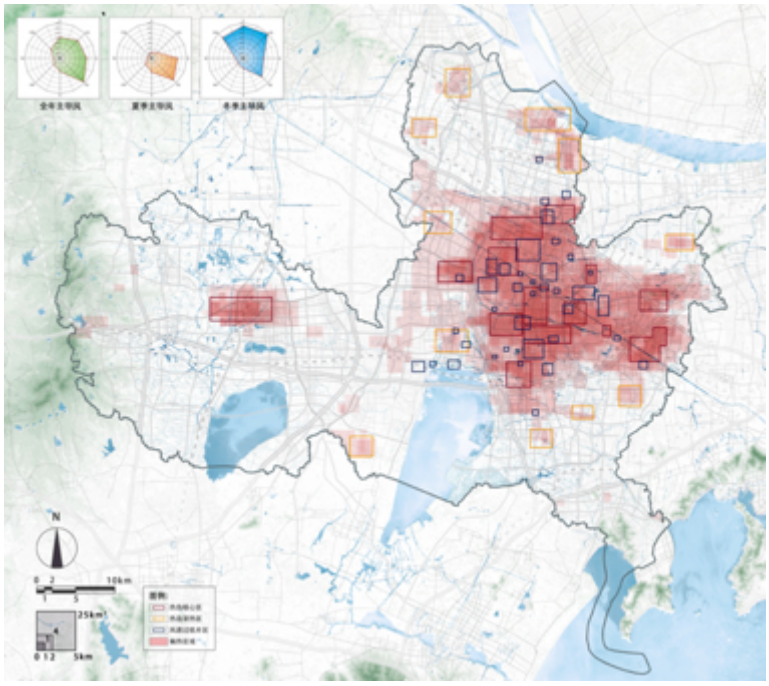


Figure 11: Wind and heat environment overlay.

3 Construction of ventilation corridors

3.1 The whole city

On one side, the wind environment simulation and the thermal environment overlay both compose the space foundation. On the other side, the base map of water, green space and the road network all compose the potential corridors. And these two both help construct the final ventilation corridors based on water and land double net. Finally, we planned the city's three-level ventilation corridors, (Figure 12) including 4 first-class ventilation corridors, whose width is not less than 150m and the length is not less than 1000m, 12 second-class ventilation corridors, whose width is not less than 50m, and the length is not less than 500m, and several third-class ventilation corridors.

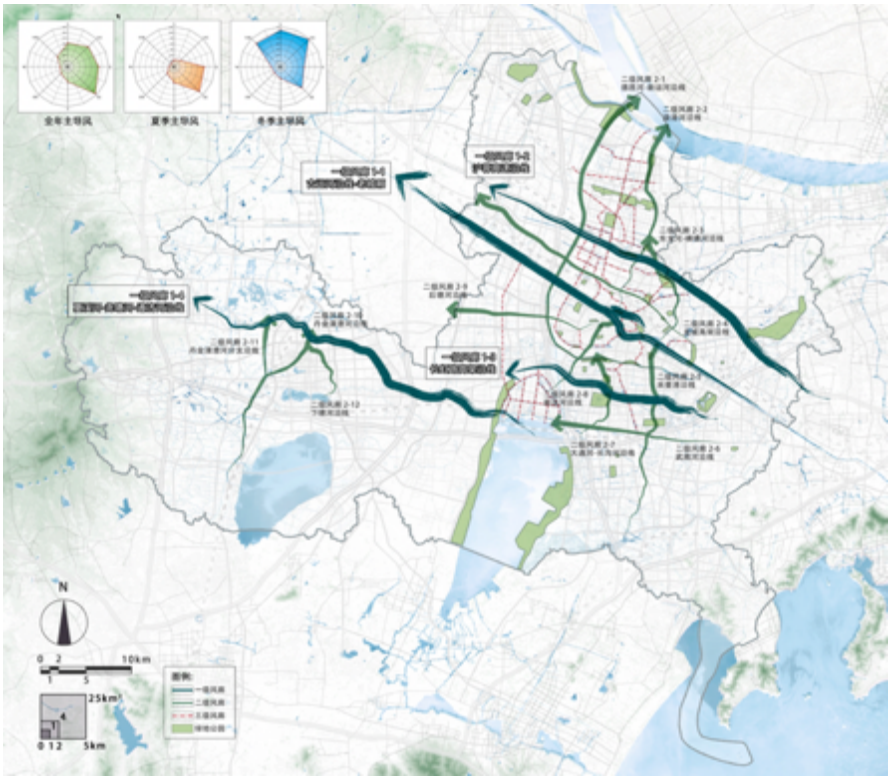


Figure 12: Ventilation corridor planning map.

Then we made some basic control of these ventilation corridors.

3.1.1 Control of the first-class ventilation corridor

The basic principle is to ensure smooth ventilation in four first-class ventilation corridors and strictly control the development and construction inside the corridor. Any tall buildings or trees are forbidden to be built inside the corridor. Furthermore, the height and density of buildings on both sides of the main water bodies or roads inside the corridor should be strictly controlled.

To be specific, the four first-class ventilation corridors should be parallel to the city's dominant wind direction (ESE), or the angle with the dominant wind direction is not more than 45 degrees. The continuous length of the four ventilation corridors shall not be less than 1000 meters, the width of each segment should be no less than 200 meters, and the aspect ratio not less than 20:1. Furthermore, we proposed some quantitative indicators including the construction intensity, distribution of public open space, water and road direction, building density, height, etc. (Table 1)

Table 1: Control of the first-class ventilation corridors.

Control elements	Standards
Proportion of construction land	≤20%
Building density	≤25%
Building height	≤10m
Wind resistance rate	≤0.6
The ratio of the height of the adjacent building at the border of the corridor to the width of the corridor	≤0.5
Opening degree	≤40%

3.1.2 Control of the second-class ventilation corridor

Similarly, we also made some control of the second-class ventilation corridors. The basic principle and the direction of corridors are similar to the first-class as mentioned above. While the continuous length of these 12 ventilation corridors shall not be less than 500 meters, the width of each segment should be no less than 80 meters, and the aspect ratio not less than 20:1. The quantitative indicators also have some differences. (Table 2)

Table 2: Control of the second-class ventilation corridors.

Control elements	Standards
Proportion of construction land	≤25%
Building density	≤30%
Building height	≤25m
Wind resistance rate	≤0.7
The ratio of the height of the adjacent building at the border of the corridor to the width of the corridor	≤1
Opening degree	≤30%

3.2 The core area of the city

To be more specific, we further studied the core area of the city. The third-level ventilation corridors were further constructed based on the water-land dual-network to connect the urban green space park in series. (Figure 13) The three-level wind corridors form a core corridor system together. At this level, except basic control, we proposed several detailed strategies to guide subsequent design, which will be introduced in detail in Section 4.

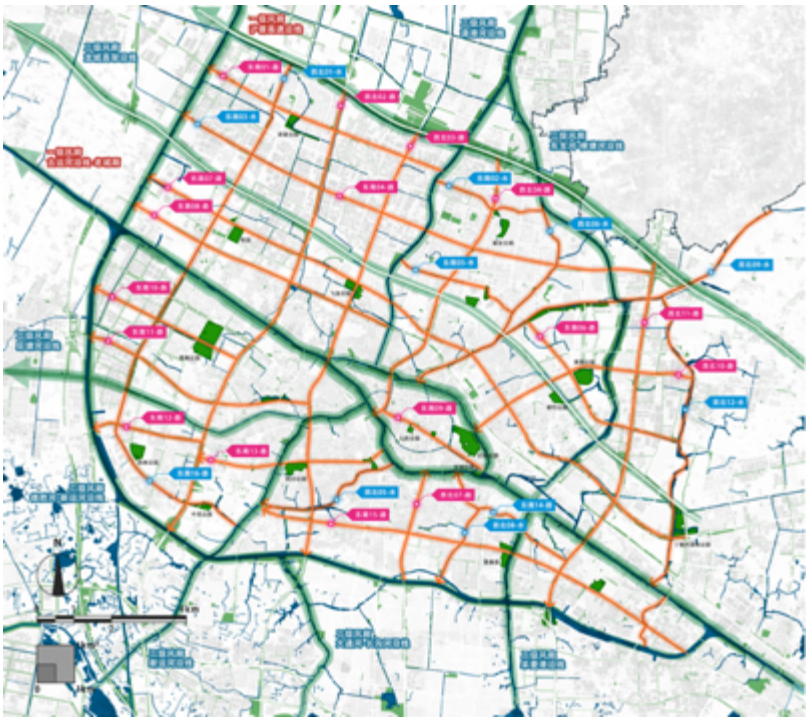


Figure 13: Core area ventilation corridor planning map.

4 Detailed strategies

4.1 In summer

According to different dominant wind directions in four seasons, we conducted simulation respectively to make a comparison. (Figure 14)

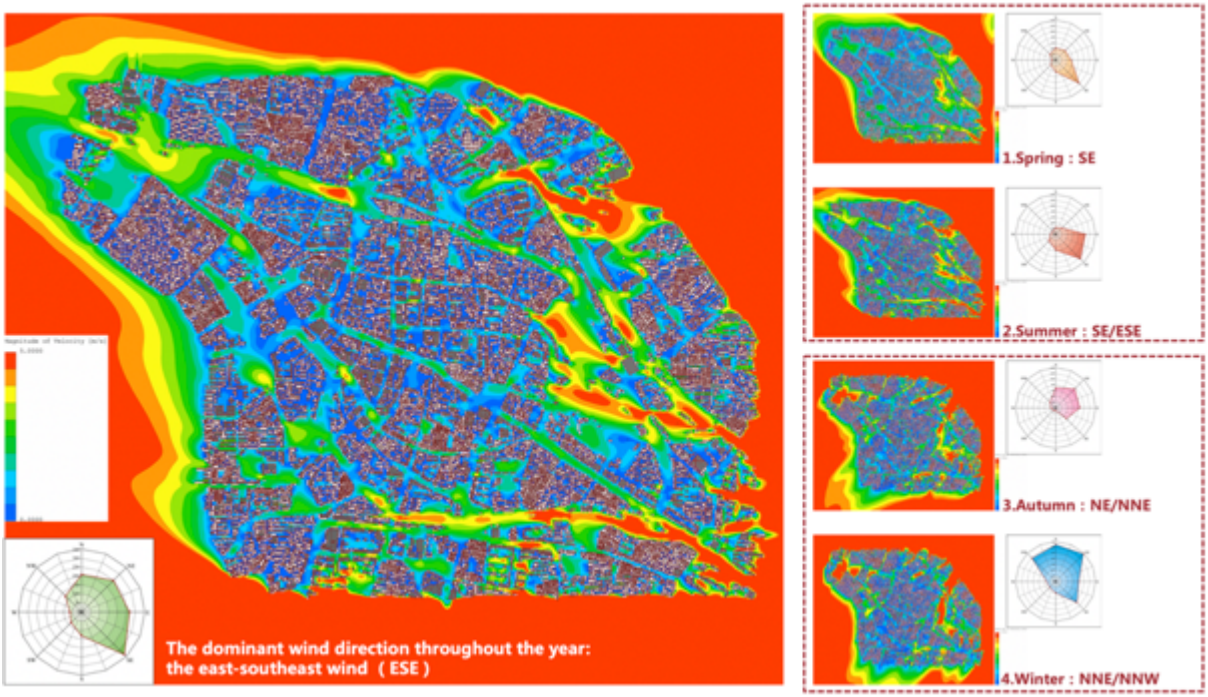


Figure 14: Simulation with different dominant wind directions.

As the wind environment is more significant for the winter and summer seasons of the city, we selected two main research directions to further analyze. In summer, we extracted related river space, street space and construction space that with low wind speed. These areas were superimposed to get the key design locations. In future urban renewal and land development, attention should be paid to the ventilation environment assessment in these areas. And we proposed corresponding suggestions in such areas:

- Connect the surrounding public open spaces squares, etc., and strictly limit the height of the building in the ventilation corridor.
- The buildings should be arranged properly. There must be enough space between the buildings. The front and rear buildings are staggered, and the central axis is as parallel as possible to the prevailing wind, so that the wind can flow between the buildings.
- The height of the buildings shall be reduced towards the ventilation corridor or the public open space, and the building on the edge of the wind gallery or public space may be set aside.
- The height of the buildings should be gradually lowered toward the prevailing wind sourc.
- The building platform should be stepped down towards the road as much as possible to improve the impact of the building on the street ventilation.

- Buildings on both sides of the main river should have sufficient ventilation space to avoid long lengths facing the river.
- Plant appropriate street trees on both sides of the main streets to strengthen urban greening.

4.2 In winter

While in winter, the wind speed should be mainly avoided. On one hand, excessive wind speed in winter makes people feel cold and uncomfortable. On the other hand, winter wind will bring urban pollution according to the analysis in Section 2. Based on the simulation of the dominant wind direction in winter, we proposed some suggestions in related areas:

- Increase the perimeter of buildings or structures, and it is not advisable to leave excessive open space.
- Increase tree greening and reduce the impact of excessive wind speed.
- Buildings around the area with excessive wind speed should be enhanced with wind-shielding measures. The main façade of the building should not be oriented towards the wind source. The influence of wind should be mitigated by architectural design techniques.

5 Conclusion

To sum up, we have done a lot of preliminary work on analyzing the current situation in Changzhou, including the heat island distribution and background wind environment according the data we achieved. Then we have summarized the areas with the most severe wind and heat environment which especially need to be planned. Furthermore, we construct three-level ventilation corridors based on water and land double nets both in the city area and core area, and propose different control strategies respectively. Finally, based on the simulation study of the dominant wind direction respectively in summer and in winter, we extract some key areas which need to be paid more attention in the future urban design, and we propose some corresponding suggestions to improve the wind environment in the old town area.

In ongoing study, we will extract those key areas and conduct further simulation to analyze specific issues. Then multi-dimension spatial morphology factors will be respectively extracted to simulate through CFD. Specific correlation strength and quantitative standards can be summarized to build the research framework for better urban ventilation. Also, we will conduct multi-scenario designs to check if the strategies can really lead to optimization.

References

Chinese University of Hong Kong. (2013). Urban Climate Map and Wind Environment Assessment Standard - Feasibility Study (Executive Summary). *Hong Kong Special Administrative Region Planning Office*. Hong Kong.

Ding, W.W., Hu, Y.P. and Dou P.P.. (2012) Study of the interrelationship between urban pattern and urban microclimate. *Architectural Journal, 07*, 16-21.

Germano, M. (2007) Assessing the natural ventilation potential of the Basel region. *Engry and Buildings, 39(11)*, 1159-1166.

Ren, C., Yuan, C., He, Z.J., Wu, E.R.. (2014). A study of air path and its application in urban planning. *Urban Planning Forum, 03*, 52-60.

Zhan, Q.M., Ouyang, W.L., Jin, Z.C., Zhang, L.. (2015) RS and GIS based ventilation potential study and planning. *Planners, 31(11)*, 95-99.

Zeng, S.P., Yun, Y.X. and Tian, J.. (2016) “Coordination” and “Join” : Research on the theory of “Source-Flow-Sink” ventilated corridor system construction and planning strategy. *Urban Development Studies, 23(11)*, 25-31+70.

Zhu Y.L., Yu L.L., and Ding S.G.. (2008). The application of urban ventilation channel for urban environment improvement. *Urban Studies, 1,* 46-49.

Contact email: 863235311@qq.com

The Study of Using the Opaque Wall Material to Manage Overall Thermal Transfer for the Heritage Hospital Façade in Bangkok

Waranyoo Siriwan, Phranakorn Rajabhat University, Thailand
Vorayod Rattanamart, Phranakorn Rajabhat University, Thailand
Roengnarong Ratanaprichavej, EEC Academy, Thailand

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
Many hospitals in Bangkok metropolitan districts are awaken to the global warming crisis. It results that the temperature in the winter is closed to the summer. The following effect is that the old hospital buildings, are confronting the energy over consumption than ever. In particular, the old facades are needed renovation to preserve comfortable condition. However, there has a limited renovation for a heritage building such the demolition in a façade component realized the maintenance of historical building character and district conservation. This article concentrates on the study the suitable opaque material finishing for the heritage hospital façade renovation. The aim is to reduce overall thermal transfer value (OTTV) of the façade related to Thailand standard requirement of Pollution Control Department (PCD). The research scope emphasizes in the opaque material of the hospital façade. Here the ward of Sirinthorn building, within Rajavithi hospital in Bangkok is selected as a paradigm. The study method is divided in 3 phases: defining a suitable format of material installation for building conservation for the paradigm, investigating opaque materials for construction following Thai Industrial Standard, and considering material character by a trail & error method. The result is the guideline of material selection presented in 3 characters. This article offers the sample opaque material to apply for the case study in practical later.

Keywords: An opaque wall, Heat transfer, Heritage hospital façade, Energy management

iafor
The International Academic Forum
www.iafor.org

Introduction

OTTV in heritage hospital building

Many hospitals in Bangkok metropolitan districts are awaken to the global warming crisis. It results that the urban temperature is hot from the winter to the summer. The following effect is that energy performance of the heritage hospital buildings in Bangkok metropolitan districts are confronting the overconsumption than ever.

After the overview of heritage state hospitals, it found their actual building lifetime to serve people is frequently over 30 years. During this period it will be renovated many times due to the shorter life of technical equipment, the development of new types of equipment, new regulations, new energy-saving technologies and the ageing of the building itself (CADDET, 1997).

The primary evaluation of Hospital building in Bangkok by Department of Alternative Energy Department and Efficiency (2008.), it founds that buildings remain potential to proceed further in energy conservation. Meanwhile hospitals are ready to promote this issue seriously.

One significant issue is the obsolescence of the existing façade material design which happen in the heritage building. The old heritage facade always malfunction in the present Bangkok climatic characteristics, especially in the Thailand summer season. The existing facade designs cannot reduce higher external heat gain from solar radiation in Bangkok zone as protected in the last decades.

In particular, the opaque wall are major area of the old hospital facades need heat transfer management between outdoor and all interior air-conditioning zones. So the façade, redefined as a special share component between in-and-out, is to practice energy conservation and the comfort condition for users in the old hospital buildings.

Similar in typical buildings, hospital facade design promotes not only the balance of heat transfer between inside and outside, but creating a comfortable zone. The overall Thermal transfer value (OTTV) concept can calculate by heat transfer via the facades. (Hui, 1991.) OTTV standard is applicable to mechanically cooled buildings, especially air-conditioning zone. OTTV is a measure of heat transfer into the building through its envelope in the unit of watts per square meters (Jeyasingh, 2010.).

Objective

This article concentrates on the study of using the suitable opaque material finishing for the heritage hospital façade renovation. The expected aim is to reduce overall thermal transfer in building by adaptive use of opaque material in facades. The design output is under Thailand OTTV code. Also the new renovation remain maintaining outstanding existing Building Character of the façade to public sight.

Methodology

The assumption of this article is based on that selecting suitable materials and its façade setup method can manage energy efficiency in heat transfer in a heritage hospital building. The heritage case differs from the new construction project by

restricting to conserve some existing architectural components following DOCOMOMO guideline (Rattanamart, 2018), consequently the research variables are categorized by dependent variables (material type and its installation method), control (Coordinating Center for Energy Conservation Building Design., 2016.) variables (site, a historic building conservation, existing components, area function and façade area), and independent variables (opaque wall characters, OTTV status and a type of wall installation).

The typical principle of façade design solution for thermal transfer management in a building is divided in 3 formats: solid (a single-layered masonry), framing studs (such a partition) and composite wall (combine techniques between material kinds) (Coordinating Center for Energy Conservation Building Design., 2016.). The highest level of the resistant value (R-Value) is the setup type of composite wall with the insulation, flexibly designed in materials (Buranasompob, 1996). The potential is assigned by the OTTV value from calculation from material character. It can be implemented by measuring the size and a characters of building façades to proceed the OTTV formula (A.L.S.Chan, 2014). Its output offers a numeric value (in the unit of watts per a square meter) to consider in the façade material selection based on the industry foundation class (IFC).

In this project methodology, energy software is selected as an optional tool for calculation higher potential than the other choices (such manual calculation). Refer to the precedent study of software for OTTV calculation compared to the manual style by Charoensuttiyotin (2017), it found that the distinct advantage of software application is proceeding in a limited time, less revenue and able to present various analysis solution. It can work for the project time management. The selected software to calculate, analysis and report the OTTV status referred to the code OTTV and its status after calculation, is the standard software BEC (Building Energy Code) designed by DEDE (Department of Alternative Energy Development and Energy Conservation, 2016.) as followed in Figure 1.

The paradigm of this research area is selected by considering in the hospital executive committee policy which is desired to develop the building conservation together with energy efficiency. The research methodology for this project is discussed in 2 aspects-energy efficiency (via OTTV) and heritage conservation as shown in Figure 2.

Data

Sirinthorn building, the hexagon shape building in Rajavithi hospital, is the outstanding architecture in Victory monument in Bangkok metropolitan. The research scope emphasizes in the opaque façade material of the fourth to tenth floor of the building, its function is an inpatient ward. Refer to the report on October 2nd, 2017 by the Sirinthorn Building renovation committee, it agrees that renovating building facades must preserve the existing façade characteristic.

Prior to analysis, the facade character and its area is surveyed to calculate (Figure 3). The scope of building façade renovation is concluded in the Sirinthorn Building renovation committees' previous report. Also according to the previous building survey, it founds that the opaque materials for existing hospital façade is the 10-centimeters thickness brick walls with white render. Its values of the opaque

specifications are 1.069 W/M•K for thermal conductivity, 1700 KG/M3 for density, and 0.79 J/Kelvin. All database from Figure 3 and its specification is inserted in BEC program in the part of database and evaluated the OTTV status.

Result and Discussion

The calculation result for the existing opaque wall is presented by the report compared to the building code OTTV. It founds that the building OTTV status is failed. Its value is 91.659 watts per a square meter, which is higher than the code, 30 watts per a square meter (Coordinating Center for Energy Conservation Building Design, 2009). The trail-and-error method (Muthuri, 2009) is applied for this project by BEC program practice to meet the building OTTV code. The required result from process is to achieve building OTTV code and heritage characters conservation.
Typical heritage conservation can practice in 2 different methods: Revitalization and Preservation. The revitalization is mainly reconstruction with adaptive use, but the preservation is defined maintaining the existing historic character (Architecture Department of the University of Hong Kong, 2012.). The Sirinthorn renovation plan is limited to work 3-4 months as shown in Figure 2. For this reason, the preservation of the historic building facades by maintain the existing facade is a more appropriated option than the revitalization. This research selects the technique of adding panel structure on the existing wall rather than masonry reconstruction to practice trail-and-error with materials. After the test, it founds that the OTTV status result is pass the test as shown in Figure 4.

Refer to the building OTTV status report, the insulation material which is recommended for this case is the 3 inches of Thickness of Fiberglass insulation with high performance label. (Or called Stay Cool 3" Super Save). Its material character specification contains the maximum values of 1) heat insulation: 0.39 W/m•K in Thermal conductivity, 2) 12 Kg/m^3 in density, and 3) 96 kJ/kg•K for specific heat (Figure 5). This research also discovers that material performance in heat transfer guideline is depended on 3 characters: Thermal Conductivity, Density and Specific heat capacity. The characters is the insulation material, this research offers “Fiberglass insulation with high performance label” as an alternative material for adding to the existing masonry material (a brick wall).

The critical consideration after use of insulation is that the whole façade thickness is increase from the existing depth in an opaque wall part (as Figure 5). It effects on the detail of and opening components such windows and doors is deeper (> 10 centimeter), the material cost of window or doors is higher.

Conclusion

In conclusion, the frame of Sirinthorn building renovation is realized that 1) selected materials should be harmony and orderly the whole building envelope. The research also recommend the three significant material characters which is influential to heat transference. And 2) respecting the heritage conservation principle by preserving the exterior façade and adapting the interior. Here adding the insulation and create more layer inside the building is an alternative solution to protect heat transfer cross the façade, meanwhile to maintain out skins of heritage building character. Also outside materials can be kept the same exterior elevation character as the previous design.

Finally the research outcome is considered in practical for Sirinthorn renovation project. Materials itself and its installation technique may be adaptive, in the term and condition that the values of material specification and design details must support building OTTV status pass.

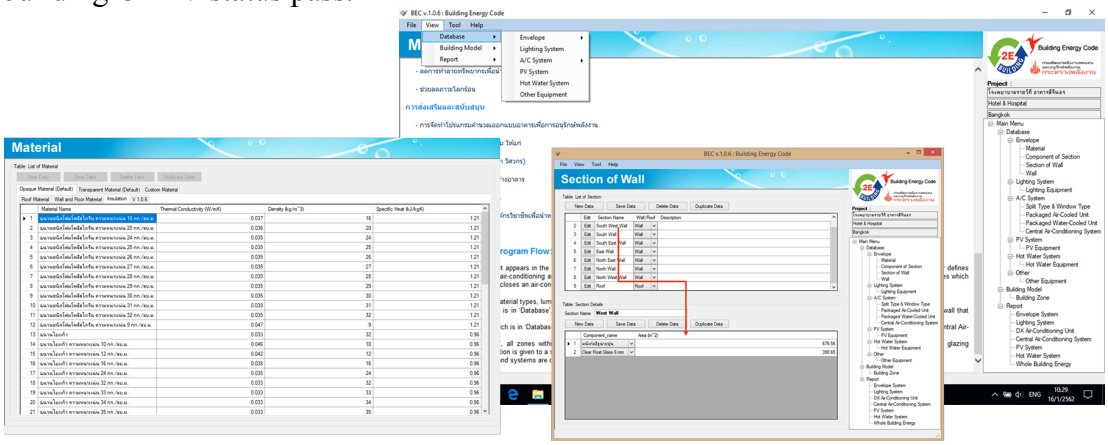


Figure 1 : BEC interface.

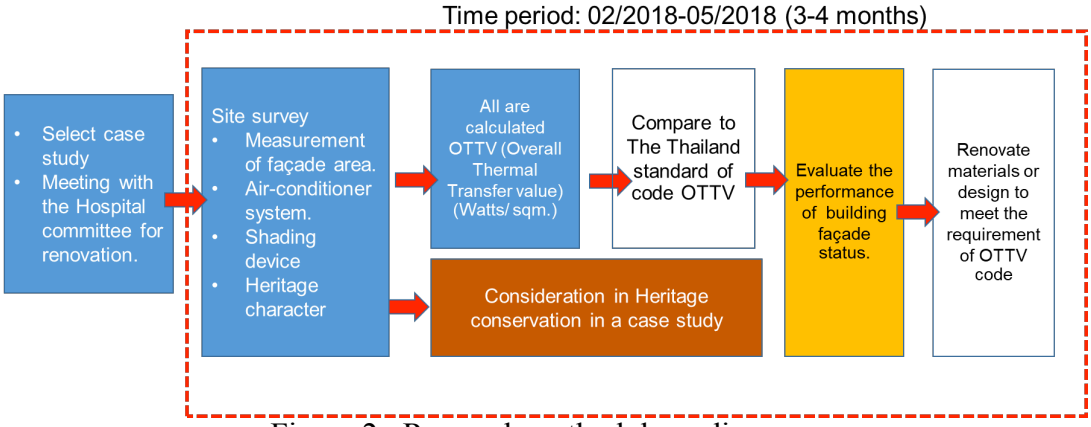
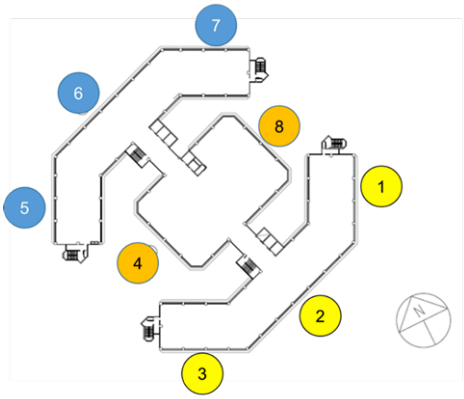


Figure 2 : Research methodology diagram.



Direction	Number	Opaque area (Sqms.)
West	4	676.56
South-West	3	479.1
South	2	856.2
East-West	1	479.1
East	8	673.14
North-East	7	501.24
North	6	856.2
North-West	5	501.24
Total	all	5040.78

Figure 3: Diagram of direction and building façade area.

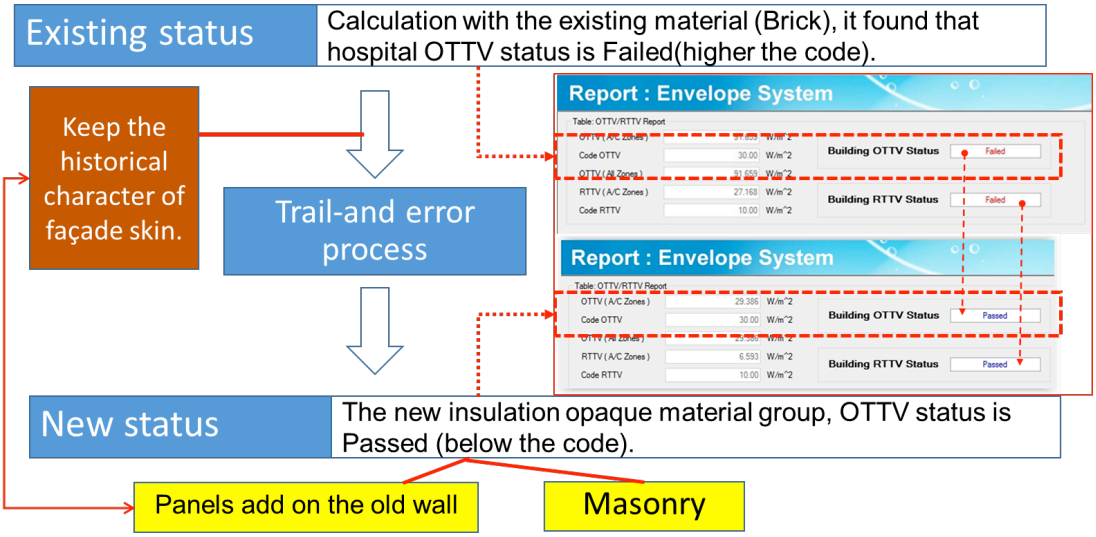


Figure 4 : Frame of result and discussion.

Material name	***Thermal Conductivity (W/m·K)***	***Density (kg/m³)***	***Specific Heat capacity (kJ/kg·K)***
3 inches. Thickness of Fiberglass insulation with high performance label. (Stay Cool 3"Super Save)	*0.039*	*12*	*0.96*

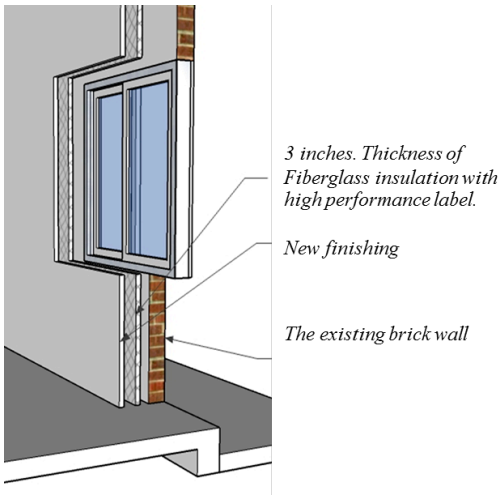


Figure 5 : The recommended optional principle solution.

References

A.L.S.Chan, T. (2014, January). Calculation of overall thermal transfer value (OTTV) for commercial buildings constructed with naturally ventilated double skin façade in subtropical Hong Kong. *Energy and Buildings.*, 14-21. doi:https://doi.org/10.1016/j.enbuild.2013.09.049

Architecture Department of the University of Hong Kong. (2012). *Science Teaching Kit for Senior Secondary Curriculum- Calculation and Application of OTTV and U-value.* (T. U. Faculty of Arhcitecture, Ed.) Retrieved June 3, 2018, from minisite.proj.hkedcity.net: http://minisite.proj.hkedcity.net/hkiakit/getResources.html?id=4061.

Buranasompob, T. (1996). *Design of Energy- efficient building.* Bangkok: Amarin Printing and Plublishing co.ltd.

C. Marinoscia, G. S. (2014, April). Experimental analysis of the summer thermal performances of unnaturally ventilated rainscreen facade building. *Energy and Buildings*(72), 280-287. doi:10.1016/j.enbuild.2013.12.044

CADDET. (1997). *Saving Energy with Energy Efficiency in Hospital.* Sittard: CADDET Energy Efficiency. Retrieved from http://www.caddet-ee.org

Charoensuttiyotin, A. (2017.). *Development of Modelling Information Modelling(BIM) to calculate the overall thermal transfer value (OTTV) in schematic design stage.* Bangkok: Chulalongkorn Uninersity.

Coordinating Center for Energy Conservation Building Design. (2009). *Coordinating Center for Energy Conservation Building Design.* Retrieved February 6, 2018, from www.2e-building.com: http://www.2e-building.com/view.php?cat=english&id=187

Coordinating Center for Energy Conservation Building Design. (2016.). *NeawTang-Buengton Nai Karn Ok-bab Akarn Anurak Palang Ngan PrasitipabSung Cheang Satapattayakum [Basic principle of Energy conservation building with architectural High performance.]*. Bangkok: DEDE. Retrieved from http://www.enconfund.go.th/pdf/Architectural-Guidebook.pdf

Department of Alternative Energy Department and Efficiency. (2008.). *Krongkarn-Suksa-Kanekarnshai-Palang-Ngan-Nai Utsahakum-Lae Akarn-Praphate-TangTang(SEC) [The study project of Specific Energy Comsumption in buildings.(SEC)]*. Misintry of Energy., Alternative Energy Department and Efficiency. Bangkok: Department of Alternative Energy Department and Efficiency. Retrieved from http://www2.dede.go.th/km_berc/downloads/menu4/%E0%B9%80%E0%B8%AD%E0%B8%81%E0%B8%AA%E0%B8%B2%E0%B8%A3%E0%B9%80%E0%B8%9C%E0%B8%A2%E0%B9%81%E0%B8%9E%E0%B8%A3%E0%B9%88/%E0%B8%84%E0%B8%B9%E0%B9%88%E0%B8%A1%E0%B8%B7%E0%B8%AD/08%20sec/01_%E0%B9%82%E0%B8%A3%E0%B

Department of Alternative Energy Development and Energy Conservation. (2016.). *Khumue Kan Chai ngan Prokraem BEC V1.0.6 [The manual guideline for Building Energy Code v.1.06.]*. Bangkok.: Department of Alternative Enrgy Development and Energy Conservation.

Edmundas Monstvilas, K. B. (2010.). HEAT GAINS IN BUILDINGS – LIMIT CONDITIONS FOR CALCULATING ENERGY CONSUMPTION. *OURNAL OF CIVIL ENGINEERING AND MANAGEMENT., 16*(3), 439–450. doi:10.3846/jcem.2010.50

Giovanna Franco, A. M. (2015). Towards a systematic approach for energy refurbishment of historical buildings. The case study of Albergo dei Poveri in Genoa, Italy. *Energy and Buildings.*(95), 153-159. Retrieved January 16, 2018

ienergyguru. (2015, June 5). *Heat Transfer Through The Building Envelope.* Retrieved from www.ienergyguru.com: https://ienergyguru.com/2015/09/heat-transfer-through-the-building-envelope/

International Council on Monuments and Sites. (2013). *Austrlian ICOMOS.* Retrieved April 13, 2018, from https://australia.icomos.org: http://portal.iphan.gov.br/uploads/ckfinder/arquivos/The-Burra-Charter-2013-Adopted-31_10_2013.pdf

Jeyasingh, V. (2010.). Concept of Overall Thermal Transfer Value (OTTV) in Design of Building Envelope to Achieve Energy Efficiency. *International Journal of Thermal and Environmental Engineering., 1*(2), 75-80. doi:10.5383/ijtee.01.02.003

Muthuri, C. (2009). Mathematic Model. In R. A.-L. Kay Coe, *Graduate Environmental and Agricultural Research A Guide to Effective and Relevant Graduate Research in Africa* (pp. 231-241). np: Regional Universities Forum For Capacity Development in Agriculture (RUFORUM). doi:10.13140/2.1.2005.0569.
Rattanamart., S. (2018). *DOCOMOMO.* Bangkok: Phranakorn Rajabhat University.

Surapong Chirarattananon, J. T. (2004.). An OTTV-based energy estimation model for commercial buildings in Thailand . *Energy and Buildings.*(36.), 680–689. doi:10.1016/j.enbuild.2004.01.035

TGBI. (2010, September 7). *Thai Green Building Institute.* Retrieved March 26, 2018, from www.tgbi.or.th: http://www.tgbi.or.th/tag/show/0

Contact email: waranyoo@pnru.ac.th

Assessing the Vulnerability of Rice Production to Climate Change in the Upper East Region of Ghana

Nuhu Mohammed Gali, University of Tsukuba, Japan
Kenichi Matsui, University of Tsukuba, Japan

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
This study assesses the vulnerability of rice production to erratic climatic patterns in the Upper East Region of Ghana. This region is known to be the most vulnerable to climate change in the country. However, no study has found any local variations as the study tended to be defined by administrative boundaries. To assess rice production vulnerability to biophysical aspects of climate change (e.g., rainfall, temperature), we applied a multiple regression and crop vulnerability index analyses. The vulnerability index was used to determine the yield loss sensitivity and exposure. The multiple regression analysis aimed to assess the impact of maximum and minimum temperatures on rice yields with negative relationship to rainfall variability. The results of rice yield sensitivity and overall vulnerability highlighted local differences. For example, we found that farmers in Talensi district were the most vulnerable in terms of exposure to erratic rainfall patterns. Also, our multiple regression analysis showed that a local variation of vulnerability was linked to residents' socioeconomic status, including poverty, literacy/education, and economically active population. These results suggest that highly localized adaptation strategies are needed through technical and institutional support to improve the resilience of food production systems.

Keywords: Vulnerability, Climatic variability, Rainfall and temperature patterns, Rice production

iafor
The International Academic Forum
www.iafor.org

1. Introduction

Crop vulnerability can be understood in terms of how the crop production system sensitively responds to climate change, including adaptive capacity (IPCC 2001b, p. 89). The Upper East Region of Ghana has experienced extreme climatic hazards, including erratic rainfall, drought, flood and high temperature (Antwi-Agyei, 2012; Nkrumah et al., 2014). Smallholder rice farmers here perceived decreasing rainfall, increasing temperature, and reduced crop yields (Abdul-Razak and Matsui, 2018). These unstable climate conditions affected rice production and productivity.

To determine crop vulnerability to weather and climate conditions past studies focused on process-based models (Challinor et al., 2009; Wheeler et al., 2000) and inter-regional variations (Issahaku et al., 2009, Antwi-Agyei, 2012). While these overall impact studies on agriculture is viable, it is also important to look at specific crop response so that our overall understanding can be further refined. This paper aims to determine the impact of climate change on rice production and smallholder farmers' adaptation measures that are needed to reduce crop vulnerability. We explore and quantify the sensitivity and exposure of rice yields to climatic hazards.

2. Study Area

The Upper East Region is located in the northeastern part of Ghana. It lies in semi-arid Guinea and Sudan savannahs. The mean annual rainfall ranges between 800mm and 1,100mm although the rainfall pattern is erratic spatially and in duration. Annual average temperatures range from 14 ^{o}C to 35 ^{o}C (Ghana Statistical Service, 2014). Agriculture employs 80% of the population in this Region. The Region is the third largest rice producer among five rice-producing regions in Ghana. About 90% of farm holdings in this Region are less than two hectares in size. Farmers here mainly use hoe and cutlass to cultivate. In some cases, they use bullocks. Rice farming is predominantly rainfed. Only limited locations like Tono and Vea dam sites are under irrigation. This means that rice yields depend on rainfall and are vulnerable to climate change (MOFA, 2016).

3. Methodology

3.1 Regression analysis

We collected the Region's climate data, including annual rainfall, maximum temperature and minimum temperature for the period (1991 to 2017) from the Savanna Agricultural Research Institute (SARI-Manga) and Ghana metrological agency (Gmet. -Navrongo). Annual rice yield data for over 27 years (1991 to 2017) were collected from the Statistics, Research and Information Directorate of the Ministry of Food and Agriculture (SRID-MOFA). We carried out a multivariate regression analysis to determine the relationship between rice yields and climatic variability. This helps to confirm the significant impact of rainfall and temperature anomalies on rice yields anomalies.

3.2 Rice yield vulnerability index analysis

Rice yield vulnerability analysis was conducted concerning Pusiga, Garu tempani, Talensi and Builsa districts. The study districts were purposively chosen based on their rainfed rice production potential mostly at valley bottoms (MOFA, 2016). Rice

yield data of the four selected districts over 27-year period (1991 to 2017) were detrended using auto regression with a 3-year lag. The auto-regression removes the effect of increased technology and allows to calculate an expected yield (Smilton et al., 2009). The expected yield was divided by the actual yield to determine the yield loss sensitivity index.

$$\text{Sensitivity Index (S)} = \text{(Expected yield)/(Actual yield)}$$

Average seasonal rainfall data of the selected districts from 1991 to 2017 within rice cropping months of May to October was divided by each year's average growing season rainfall for the same period to determine the exposer index.

$$\text{Eposer Index(E)} = \frac{\text{Average long term growing seasonal rainfall } (1991-2017)}{\text{Average growing season rainfall for each year}}$$

To determine the vulnerability of rice yields to erratic rainfall pattern we divided the yield loss sensitivity index by the exposer index in line with (Antwi -Agyei, 2012)

$$\text{Vulnerability index} = \frac{\text{Yield loss sensitivity Index(S)}}{\text{Eposer Index (E)}}$$

4. Results and Discussion

4.1 Rice yield response to climatic variability

Table 1 shows the results of the regression analysis regarding the impact of climatic variabilities on rice yields. It indicates that rainfall and temperature anomalies significantly affected rice yields over time. Rice yields variation had a coefficient of (-8.814) significant at 5%. This indicates that yields of rice significantly decreased with time. Rainfall trends in the UER had varied (28%) and decreased by 44.6% for the past decade (Abdul-Razak and Matsui 2018). This finding conforms with the negative relationship observed between rainfall and rice yields in our regression analysis. The overall results show an R–square value of 0.472, implying that the impact of climatic variabilities accounted for (47%) of the total variations in rice yields as observed in the study region.

Table 1 Results of multiple regression for Yield(t)

Variables	Coefficient	Std Err	t-value	p-value	Lower limit	Upper limit
Constant	-8.814	3.649	-2.415	0.024	-16.362	-1.265
Rainfall(mm)	-0.001	0.000	-2.491	0.020	-0.002	0.000
Temp (Mini)	0.215	0.106	2.023	0.055	-0.005	0.435
Temp (Max)	0.207	0.053	3.879	0.001	0.097	0.318

NB: Summary measures

Multiple R	R-Square	Adj R-Square	StErr of Est
0.687	0.472	0.403	0.387

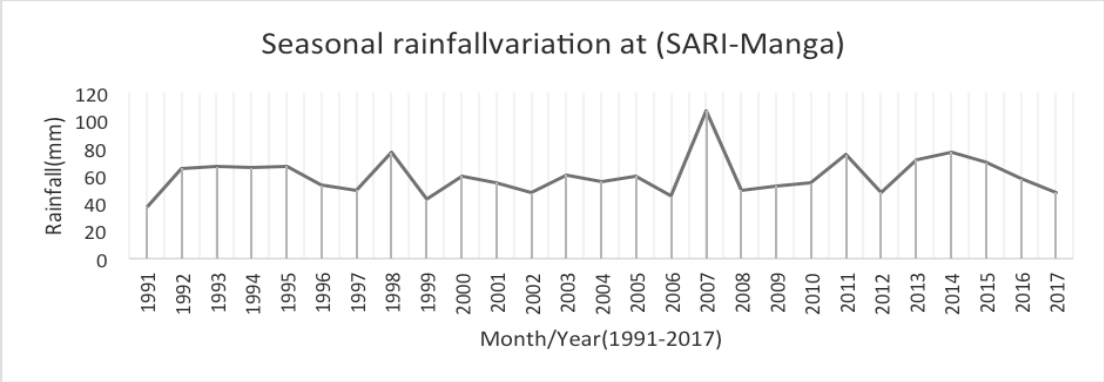


Figure 1 Observed seasonal rainfall variability for the Upper East Region

4.2 Rice yield sensitivity and vulnerability to erratic rainfall pattern

Figure 2 shows the overall sensitivity and vulnerability of rice production to climatic variability. The results indicate that Talensi district had the highest vulnerability index (1.113) followed by Pusiga district (1.104) and Garu tempani district (1.042) respectively. Builsa district was the least sensitive. Geographically the most exposed and sensitive districts were located in the Sudan savannah zone. This zone receives the lowest average rainfall of 958mm per annum (Armah et al., 2010). Upland rice farming in the Sudan savannah is prone to drought, with some farms located at riverbanks and valley bottoms least sensitive and resilient to drought conditions. Districts located within the Guinea savannah (Talensi and Builsa North) are more exposed to climatic stresses. Rice farming in this zone are vulnerable to flooding especially at valley bottoms but least sensitive to drought conditions, attributed to the water retention and soil fertility of these areas.

The main cause of high sensitivity is attributable to the increase in average yearly temperature, decreased rainfall and high incidence of extreme climatic conditions. The projection study shows that the Upper East Region would further experience decreasing rainfall and increasing temperature in the future (Issahaku et al., 2016).

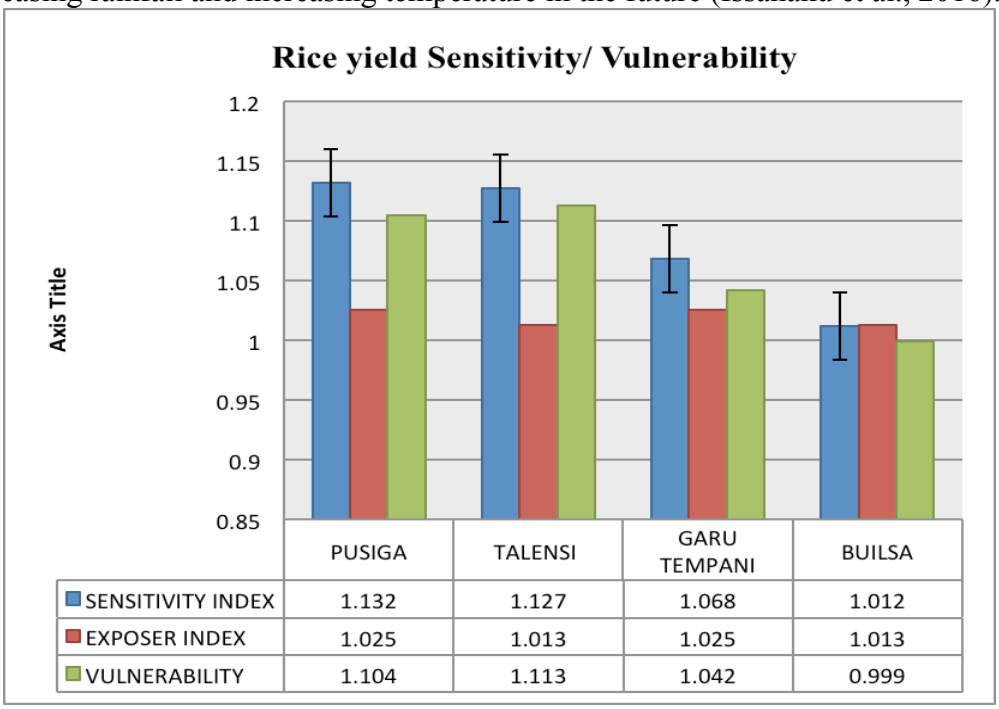


Fig 2: District scale rice yield sensitivity/vulnerability

(Scale 0.0 to 2.0) , < 1.0= Normal , > 1.0 = Sensitive/Vulnerable

4.3 Socio-economic factors that influence vulnerability and coping capacity

The results of our multiple regression analysis indicated that the vulnerability of Talensi, Pusiga, Garu tempani and Builsa south districts was linked to low socioeconomic status, such as low economically active population, illiteracy and poverty (Tables 2). According to UNISDR (2014) the capacity to cope requires continuous awareness, skills, resources and good management. The low literacy rate limits an access to climate information, limited knowledge on adaptation strategies. Insufficient economically active population limits labor availability, leading to weak farm coping capacity. Also, weak asset base as a result of poverty reduces the capacity to cope with climate change hazards. Low-income smallholder rice farmers face a shortage of agricultural inputs (Dow, 1992).

Table 2 Multiple regression analysis of socio-economic status and climatic vulnerability

Variables	Coefficient	Std Err	t-value	p-value	Lower limit	Upper limit
Constant	0.00170	0.02635	0.06434	0.95120	-0.06604	0.06943
Poverty Incidence	0.00817	0.00179	4.55972	0.00606	0.00356	0.01278
Literacy rate	-0.01577	0.00411	-3.83858	0.01214	-0.02632	-0.00521
Active population	0.01626	0.0255	6.38208	0.00140	0.00971	0.02281

5. Conclusion

This paper assessed the vulnerability of rice production to climate change in the Upper East Region of Ghana. Our results showed that climatic variabilities significantly impacted rice yields in the study area. Our analysis showed that the vulnerability of rice production spatially varied, depending partly on the adopted production system. These results support Agyei's (2012) findings on the vulnerability of crop production to drought in Ghana. This study showed a strong need for districts to make crop-specific adaptation strategies in the study area. Therefore, we recommend further studies for a localized adaptation strategy. Research and extension support (e.g., climate information, technology transfer and farmer networking) can buttress farmers. To enhance resilience, these farmers may adopt livelihood diversification strategies (e.g., livestock rearing, dry season irrigation farming, pitty trading).

Acknowledgments

We are grateful to the Statistical Research and Information Directorate of the Ministry of Food and Agriculture, Ghana, the Upper East regional Department of Food and Agriculture and the Savannah Agricultural Research in Manga for support in collecting the data for this paper.

References

Al-hassan, S. (2011). Production Risks and Coping Mechanisms: The Case of Rice farmers in the Upper East Region of Ghana. Forum for Agricultural Risk Management in Development (FARMD).

Antwi-Agyei, P., Fraser, E. D., Dougill, A. J., Stringer, L. C., & Simelton, E. (2012). Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data. *Applied Geography*, *32*(2), 324-334.

Armah, F. A., Yawson, D. O., Yengoh, G. T., Odoi, J. O., & Afrifa, E. K. (2010). Impact of floods on livelihoods and vulnerability of natural resource dependent communities in Northern Ghana. *Water*, *2*(2), 120-139.

Assembly, U. G. (2016). Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction A/71/644. Retrieved from undocs. org.doi:10.1002/2016EA000161

Challinor, A. J., Ewert, F., Arnold, S., Simelton, E., & Fraser, E. (2009). Crops and climate change: progress, trends, and challenges in simulating impacts and informing adaptation. *Journal of experimental botany*, *60*(10), 2775-2789.

Dow, K. (1992). Exploring differences in our common future (s): the meaning of vulnerability to global environmental change. *Geoforum*, *23*(3), 417-436.

Ghana Statistical Service. 2013. Regional Analytical Report – Upper East Region. Population and Housing Census. Accessed December 29, 2018. http://www.statsghana.gov.gh/docfiles/2010phc/2010_PHC_Regional_Analytical_Reports/Upper East/pdf.

Issahaku, A. R., Campion, B. B., & Edziyie, R. (2016). Rainfall and temperature changes and variability in the Upper East Region of Ghana. *Earth and Space Science*, *3*(8), 284-294.

McCarthy, J. J., Canziani, O. F., Leary, N. A., Dokken, D. J., & White, K. S. (2001). *Climate change 2001*.

Nkrumah, F., Klutse, N. A. B., Adukpo, D. C., Owusu, K., Quagraine, K. A., Owusu, A., & Gutowski, W. (2014). Rainfall variability over Ghana: model versus rain gauge observation. *International Journal of Geosciences*, *5*(7), 673.

Simelton, E., Fraser, E. D., Termansen, M., Forster, P. M., & Dougill, A. J. (2009). Typologies of crop-drought vulnerability: an empirical analysis of the socio-economic factors that influence the sensitivity and resilience to drought of three major food crops in China (1961–2001). *Environmental Science & Policy*, *12*(4), 438-452.

Stringer, L. C., Dyer, J. C., Reed, M. S., Dougill, A. J., Twyman, C., & Mkwambisi, D. (2009). Adaptations to climate change, drought and desertification: local insights to enhance policy in southern Africa. *Environmental Science & Policy*, *12*(7), 748-765.

Wheeler, T. R., Craufurd, P. Q., Ellis, R. H., Porter, J. R., & Prasad, P. V. (2000). Temperature variability and the yield of annual crops. *Agriculture, Ecosystems & Environment*, *82*(1-3), 159-167.

Winter-Nelson, A., & Aggrey-Fynn, E. (2008). Identifying opportunities in Ghana's agriculture: Results from a policy analysis matrix.

Zakaria, A. R., & Matsui, K. 2018. Farmer's Perceptions about Climate Change in the Upper East Region of Ghana. Accessed December 22, 2018. https://papers.iafor.org/submission39285/.

Cultivating Concrete Utopia: Understanding How Japan's Permaculture Experiments are Shaping a Political Vision of Sustainable Living

Leila Chakroun, University of Lausanne, Switzerland

The Asian Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
While the Japanese culture has long fascinated because of its respect for nature, this did not prevent Japanese society from significantly fueling some of today's most burning agro-environmental issues. More recently however, in reaction to the increasing recognition of the problems posed by the industrial agriculture model, diverse alternative models of food production have emerged throughout the country. Within these alternative models, the case of permaculture is particularly interesting, as it merges internationally shared targets for sustainable agriculture with socio-cultural features of sustainable living. Indeed, permaculture was originally constructed from the terms "permanent," "agriculture," and "culture" and it has spread rapidly as a social movement promoting ways of living that tackle sustainability through the nexus between nature, culture and agriculture. Building on the data collected through participant observation and semi-structured interviews with Japanese permaculture practitioners, this paper gives an overview of the vision of sustainable living shared and conveyed by Japan's permaculture movement, and attempts to show *from where* this vision is experimented. In order to spell out the double bind in which the permaculture movement seems to be caught, I use the concept of "concrete utopia," which refers to concrete experiments with sustainable living that, while localized in time and space, nevertheless carry within them the seeds of a possible – but still utopian – generalization. I thus show how the Japanese permaculture movement seeks sustainability *within* Japanese culture. The Japanese case highlights how cultural and environmental sustainability mutually reinforce each other and thereby enriches the concept of concrete utopia.

Keywords: Permaculture; sustainable agriculture; sustainable culture; concrete utopia; transition pathways; alter-politics.

iafor
The International Academic Forum
www.iafor.org

Introduction: Permaculture experiments of sustainable living as an independence/interdependence dilemma

In this paper I propose to shed new light on the tension between independence and interdependence – the theme of the 2019 Asian Conference on Sustainability, Energy and the Environment (ACSEE) – by means of the concept of "concrete utopia." This tension seems to be a paradox that is symptomatic for sustainability (Lockyer & Veteto, 2015): we need to imagine and create a sustainable world – to make ourselves independent – while for an indeterminate time remaining materially and culturally dependent on the present (unsustainable) world. In other words, any attempt to go beyond the extant social system puts us in the uneasy position of having to criticize it while still being embedded in it, making the "widely promoted concept of sustainability […] ultimately utopian in nature; it is the good state that we must strive for but may not actually exist except in theory" (Lockyer & Veteto, 2015: 52).

I make use of the concept of concrete utopia as a framework to analyze and reflect on the data I have been collecting between 2017 and 2019 during ethnographic fieldwork on the permaculture movement in Japan. It enables me to underscore the dilemma in which permaculture is caught in terms of transition pathways: the scaling-up of what may at first sight look like a-political ecological gardening experiments is, in fact, a highly political issue. The concept of concrete utopia makes it possible to deploy the complex and intricate relations that permaculture has built with the hegemonic system, and to show how challenging it is to think about permaculture without – i.e., in a total independence from – that system.

The paper is structured in four parts. It starts with a description of permaculture and how it merges sustainable agriculture and sustainable living in order to propose a consistent, all-encompassing model of society that could "compete" with the hegemonic, unsustainable system. The second part focuses on Japan, with a short historical overview of its permaculture movement. It also reviews the recent rise of social movements in Japan and how Japanese citizens are more and more aware and critical of the limits of their current model of society. The third part addresses these tensions through the concept of concrete utopia, and shows how permaculture distinguishes itself in the specific way it "makes use" of the system it criticizes. The last part concludes with a perspective on how thinking in terms of concrete utopia sheds light, in any original way, on the possible future developments of the permaculture movement.

1. Permaculture: A transnational network of place-based movements

The issue of sustainability in agriculture has gained momentum in reaction to the increasingly problematic consequences of the industrial agriculture model. As a result, diverse alternative models of food production have emerged under headings such as organic agriculture, natural farming, agroecology, and permaculture. In my own research, I focus on permaculture – a concept coined from the words "permanent," "agriculture," and "culture" in the 1970s (Mollison & Holmgren, 1978), at a time when environmental problems became increasingly visible and acquired a material presence on the international stage.

Ever since its invention, permaculture has gradually expanded its scope of action and nowadays refers to a myriad of different practices reaching significantly beyond agriculture and food production (Holmgren, 2002). It has become a worldwide social movement structured around the nexus of permanent agriculture and permanent culture (Morel, Léger, Ferguson, 2018). Permaculture is therefore not so much an agricultural method as it is a framework to design and implement more sustainable socio-agricultural systems. It was originally founded on three pillars: the know-how and wisdom of Australian aborigines, the philosophy and methods of the Japanese farmer Fukuoka Masanobu, and recent scientific findings in soil science and landscape ecology. On this threefold basis, the originators of permaculture, Bill Mollison and David Holmgren, defined permaculture as *a creative design process based on whole-systems thinking informed by ethics and design principles. This approach guides us to mimic the patterns and relationships we can find in nature and can be applied to all aspects of human habitation, from agriculture to ecological building, from appropriate technology to education and even economics"* (Holmgren, 2002).

For educational purposes, Holmgren and his team picture this design framework in the form of a flower (see fig. 2 below). It captures the manner in which the ethics and design principles of permaculture should, in their eyes, infuse all parts of human life rather than merely limit itself to agriculture. The "permaculture flower" gives an insight into what society would look like if we implemented the "permaculture paradigm" (Arnsperger, 2019). There would be non-chemical edible polycultures, lush forest gardens, with a distribution of agricultural products through local markets and community-supported agriculture (*Teikei* in Japanese). As for economic exchanges, there would be a better mix of currencies at local, regional, national, and international levels, including local and complementary currencies, to support emerging local eco-friendly markets and companies. In domains of land tenure and construction, we would see a rise of community-owned land and ecological buildings inspired by traditional know-how but improved to reach ecological requirements (cf. Holmgren, 2002). To implement such changes, we would need a complete and profound mutation of mindsets in order to readjust our existence as humans to the rest of the living realm (Chakroun & Linder, 2018; Arnsperger, 2019).

In reaction to this multi-dimensionality, the academic literature has itself approached permaculture in a plurality of ways. On the farm level, French and US agronomists (Ferguson & Lovell, 2017; Léger *et al*., 2018) have investigated the conditions of viability of this new model of ecological agriculture. On a societal level, permaculture has been identified as a potential driver for the ecological transition of social and agricultural systems (Ferguson & Lovell, 2014; 2015; Hathaway, 2016) and for the implementation of a participatory and landscape-based approach to territorial planning (Dugua & Chakroun, 2019). It has also become the focus of more philosophically oriented studies, which conclude that permaculture offers a new set of imaginaries for the Anthropocene (Roux-Rosier, 2018), opportunities for mutually beneficial relationships with nature (Puig de la Bellacasa, 2012; Centemeri, 2017), and a source of inspiration for a more existentially rooted form of nature education (Arnsperger, 2019). Permaculture design can therefore be regarded as an art of reinhabiting the Earth with care (Centemeri 2019), requiring what Pignier (2017) calls "design *with* living beings."

In my own research on permaculture, I adopt a more contextual and culturally differentiated approach to sustainable agriculture and to ecological transition, and I focus on the two cases of Switzerland[1] and Japan. This allows me to shed new light on three frequently neglected aspects of sustainable agriculture: the sensorial, the societal, and the territorial aspects.

2. "Another Japan is possible": Japan's permaculture movement in history

Permaculture's roots in Japanese culture are widely acknowledged. The founders of permaculture in fact based their concept partly on traditional Japanese farming methods and philosophy. Even the name "permaculture" was inspired by what the agricultural scientist Franklin Hiram King designated in 1911 as "permanent agriculture" after observing the farming practices and the soil fertility management of the time in China, Korea, and Japan (Paull, 2011). Mollison and Holmgren were also greatly inspired by the philosophy of the Japanese farmer Fukuoka Masanobu, one of the founders of the "natural farming movement." Fukuoka's book, *One-Straw Revolution: Introduction to Natural Farming* (originally published in 1975), has become a classical reference in the permaculture world.

But interestingly, and perhaps because of this constant praise for Japan's traditional culture within and outside the country, permaculture – which was, after all, as a foreign concept – did not spark all that much interest in Japan itself. For a long time, its development was driven by a very small group of pioneers who encountered permaculture in 1993 thanks to the publication of the Japanese translation of Bill Mollison's book, *Introduction to Permaculture*[2] – the first permaculture book ever to be released in Japanese. From then on permaculture slowly started to gain a modicum of popularity, mainly thanks to two men: Shidara Kiyokazu, a rice farmer at the time, and Itonaga Koji, a landscape architect. They both travelled to Australia to take a permaculture class at the famous permaculture hotspot of Crystal Waters, and this allowed them to organize the very first Japanese permaculture workshop in Nagano Prefecture in 1993. They then decided to create a permaculture school, the Permaculture Center Japan (PCCJ) in Kanagawa Prefecture, in 1996. That same year, Bill Mollison decided to visit Japan and was able to inaugurate the PCCJ. A non-profit organization was created later, in 2005, in order to support and ensure the PCCJ's continuity. Meanwhile, several permaculture courses were held in different areas, such as the "Urban Permaculture Course" in Tokyo in 2004. That year and the following, David Holmgren, with the help of Itonaga Koji and Shidara Kiyokazu, came to Japan twice to investigate the indigenous, traditional features of Japanese agriculture and food culture, which share significant common ground with permaculture (see Holmgren, 2004, the article where he reports his findings).

After attending permaculture courses, most of the graduates started their own projects and some collaborated to create regional permaculture associations: the group Permaculture Kansai[3] in 2007, Permaculture Kyushu in 2008, Permaculture Okinawa in 2009, and Permaculture Hokkaido[4] in 2013. The Tokyo Urban Permaculture group

[1] The Swiss case will not be addressed in this paper.
[2] Originally published in 1991.
[3] The region of Kansai is located 300 km to the west of Tokyo and gathers cities such as Kyoto, Osaka, and Kobe.
[4] The Island located North of the main Island.

was created in 2011, shortly after the Fukushima nuclear accident, by a small group of activists who wanted to "regenerate Tokyo into an urban culture that supports life rather than consuming it."[5] This "urbanization" of permaculture enabled the movement to extend beyond rural areas and to acquire new members from several of the huge metropolitan areas of Japan. More recently, two new permaculture centers were created (2016-2017): Stonebridge Permaculture Forest Garden in the Prefecture of Chiba and the Permaculture Center Kamimomi in the Prefecture of Okayama (see fig. 1 below). Both are located next to densely forested areas and have therefore infused their permaculture model with the wisdom of Satoyama – the traditional way of managing the surrounding forests and of living harmoniously with the natural elements. New forms of collaboration thus emerge between the need to revive some vanishing features of traditional Japanese culture and the worldwide experiences of the permaculture network (Itonaga, Shidara & Konuma, 1997).

Figure 1: Drawing of the Permaculture Center Kamimomi illustrating the different elements and zones included in permaculture design. Credits: Permaculture Center Kamimomi, 2017

In Japan, the permaculture movement can be understood as part of what Oguma (2016) designates as "the new wave of social movements." This new wave, also called the "new protest cycle" (Chiavacci & Obinger, 2018), is named is such way as to signify the awakening of Japan's "slumbering activist culture from decades of sleep" (Ogawa, 2016). During the decades from the mid-1970s to the 2000s, social movements were not strictly absent but they were localized, focusing – in the case of environmental movements – on locally occurring pollution and what might now be referred to as "Not In My Back Yard" (NIMBY) issues in reaction to construction projects of nuclear power plants (Chiavacci & Obinger, 2018).

The recent resurgence of protests at a national level, after this relative absence, happened "in the context of three conjunctural forces: neoliberalism, militarism, and nationalism" (Chan, 2008: 2). The resurgence, led by social movements that formed in the 1990s (Chan, 2008; Chiavacci & Obinger, 2018), happened mainly through two historical moments. The first, identified by Amagasa (in Chan, 2008: 136), is the

[5] https://www.tokyourbanpermaculture.com/english

campaign against the import of Monsanto's genetically modified wheat in 2004, under the banner "Another World Is Possible," and contributes to the revival of alter-globalization activism (*ibid.*). The second is fueled by citizens' increasingly anxious discontent about the way in which the government has tackled the consequences of the three-pronged catastrophe of Fukushima (i.e., the earthquake, the tsunami, and the meltdown of the nuclear reactor) (Ogawa, 2016). It has given a significant impulse to grassroots environmental movements, especially since the citizens cannot really count on environmental organizations because of their "widespread co-optation by a political and industrial establishment that has, since the Kyoto Protocol, promoted nuclear energy as a solution to global warming" (Dreiling, Lougee & Nakamura, 2015: 1).

In the shape and role it has acquired today in the Japanese context, permaculture sets itself apart from the more confrontational political activism characteristic of post-Fukushima protests. Permaculture resembles more what Hage (2015) proposed to call "alter-politics" – a form of action driven less by oppositional concerns than by the search for, and experimentation with, radical alternatives. The political dimension of the permaculture movement today is therefore not to be found in public spaces, but rather expressed discreetly in everyday practices and in specific, relatively unknown places. The political message of permaculture experiments lies in their very literal *rootedness:* permaculture materializes in ways that are not mobile in space and that require several years of engagement in one particular location. It is true that the permaculture movement includes the refusal of both industrial agriculture and capitalist society, but this rejection does not lead to confrontational, ephemeral protests and demonstrations. Instead the political practice of permaculture develops in the form of direct but long-term, engaging actions, such as collective gardens, agroecological farms, and community cafés. It may convey its specifically political message at a later stage, when the alternative is already well implemented and part of society, and when politicians are no longer able to simply say "no" to the project.

Since its emergence twenty-five years ago, the Japanese permaculture movement has gradually expanded and, although there are no official numbers, the network is believed (by the members themselves) to include between 15,000 and 20,000 people. The network is mainly sustained by two means: regular meetings and collaboration between members, and the sharing of information about their practices and events through personal blogs and various NPOs' webpages and social networks. The relaying of information on the Internet is, in fact, characteristic of recent post-Fukushima movements (Oguma, 2016). It is one of the "transnational networking strategies" (Lockyer & Veteto, 2015: 114) through which practitioners open up the possibility of connecting place-based commitments with what is happening in permaculture movements of other regions of the world.

However, despite its positive dynamics and its recent rise in popularity among urban dwellers, permaculture is still all but unknown to most Japanese citizens and relatively ignored by the national governments and ministries.[6] It is precisely this gap between the long history and the current buzz of permaculture within a specific

[6] With the exception of the Ministry of Environment, which lists permaculture as one of the strategies to revive traditional places of coexistence with nature (under the name of "the Satoyama Initiative"). https://www.env.go.jp/nature/satoyama/syuhourei/pdf/pe_2.pdf

section of the Japanese population, and the invisibility of permaculture for the remaining majority, that I wish to tackle through the concept of concrete utopia.

3. The concept of concrete utopia: Between hope and political struggle

Doing research on ecological transition requires that one identify where the potential levers of social transformation reside. As described in the previous section, the permaculture movement merges the issues of sustainable agriculture and sustainable living and thus sheds new light on the sustainability of agriculture, currently empowering people to change not only this specific sector, but to create the basis for a completely new vision of sustainable living. I make use of the concept of "concrete utopia" to address the tension between the materiality and spatiality of the permaculture experiments of sustainable living, on the one hand, and the ideality of the radically new model of society they are conveying, on the other. Etymologically, the concept of "utopia" plays on the ambiguity of the Greek words "*ou-topia*" (no place) and "*eu-topia*" (good place) to designate an as yet placeless ideal. It was created by Thomas More in the sixteenth century (Lockyer & Veteto, 2015) and publicized in his critical essay on the repressive government of the time, *Of a Republic's Best State and of the New Island Utopia*.

The concept of "concrete utopia" was proposed much later by the German philosopher Ernst Bloch (1885-1977), who was greatly influenced by the writings of Karl Marx and by the situation of his time: the dark period of the two World Wars, especially the rise of Nazism (he was from a Jewish family). Bloch bases his notion of concrete utopia on the assumption that humans have the possibility and the ability to transform their world and therefore to change the extant system. This assumption was not shared by the early pragmatist American thinkers such as William James, who admitted that another system might have been better but never considered a change of system to be feasible. This difference in perspective is crucial, since it attributes a totally different agency and power to the people in navigating the system they are in. Bloch also created the concept to go beyond Marx's thought, in which, according to him, materialism is too simply opposed to idealism (Hage, 2015). The power of "concrete utopia" thus lies in its ability to critique the mono-realism characteristic of Western modern philosophy: "the idea that there is one, and only one, reality that our thought is, or can be, connected to," and according to which "thought that corresponds to a reality is described as materialist, and thought that doesn't is described as idealist" (Hage, 2015: 327). Permaculture acts as a proof that we are "always inhabiting a multiplicity of intersecting spatialities and realities" (*ibid.*); its political dimension lies in the way it sheds light on the current dominant reality of environmentally destructive capitalism, which is repressive and even destructive of the multiple other "minor realities in which we are equally enmeshed" (*ibid.*).

The contemporary German philosopher Arno Münster, a specialist of Bloch's thought, has recently revived the concept of concrete utopia. He lends it an ecological interpretation and even proposes a new corresponding form of governance: eco-socialism (Münster, 2013). Starting from the concrete utopia of Bloch, which he conceives as "the projection of desires and dreams of the advent of a better world onto the sphere of feasible possibilities," Munster suggests the concept of "ecological utopia." This concept is interesting because it designates a response to the ecological challenges faced by our societies that is simultaneously feasible, possible, *and utopian*

(Münster, 2013; Dinerstein, 2016). In Bloch's and Munster's thinking, "utopian" does not mean "unrealistic" – but rather "desirable, as yet unrealized." The objective of ecological utopia is to realize the transition towards a sustainable world through the transformation of the relationships between humans, nature, and the environment.

In parallel to the above works, several related concepts have emerged to further characterize the possibilities to transform the system through grassroots actions motivated by reflection and hope. Among these are *Real utopia* (Wright, 2013), *Spaces of Hope* (Harvey, 2000), *Critical acceptance* (Arnsperger, 2009), as well as *Ecological utopia/ Ecotopia* (Lockyer & Veteto, 2015). Without going into the details of each of these concepts, I personally prefer to use concrete utopia, in part because it conveys not only the idea of experimentation but also the presence of political struggle what Dinerstein (2012) calls interstitial revolution. In addition, the epithet "concrete" displays an epistemologically interesting ambiguity it has in English: *cum-crescere* means literally "to grow together" (Berque, 2015). The concept therefore conveys the tension inherent in our paradoxical relation – of dependence, interdependence, and independence – with the extant social and economic system. This particular position is what I designated earlier as non-confrontational "alter-politics" (Hage, 2015).

4. Can we characterize Japan's permaculture movement as a concrete utopia?

The concept of concrete utopia is based on concrete actions which embody a critique of, and resistance to, the present (Deleuze and Guattari, 2003, cited in Grinberg & Machado, 2018), while rooted in future prefigurations (Dinerstein, 2012; 2016). Even micro-scale experimentations which share values that radically differ from those of hegemonic society are a way of materializing the refusal of that system and of "destabilizing the inevitability of a future that comes before us as catastrophe" (Rose, 2007, cited in Grinberg & Machado, 2018).

In the case of permaculture, these grassroots actions share ecological values and a human-centred ethic. Even though they remain marginal, these micro-scale experimentations are nevertheless prefigurating a sustainable vision of society – but one only shared, for the moment, within permaculture and related movements. As a network, they are therefore opening new possibilities for the future by creating the basis for a different model of society.

Permaculture has developed in multiple directions and dimensions. In the following picture, I propose to illustrate how each of the dimensions of permaculture, as identified by David Holmgren, materialize within the Japanese movement.

Figure 2: ***How Japan's permaculture experiments are shaping a new vision of sustainable living.*** **Photo credits: Leila Chakroun (2017-2018). Credit for the drawing: Permaculture Center Kamimomi. Credit for the Permaculture Flower: Holmgren Services.**

Starting for the upper left-hand corner, one can see the daily harvest of a permaculture garden; rice husk covering the soil to preserve its humidity and its quality; a spiral herb garden built with local rocks and growing about ten species of herbs in a very confined space; an ecological house built by a group of skilled permaculturists, merging traditional methods and innovative ecological elements; the preparation of the soil before planting winter wheat; the spraying of efficient microorganisms (EM) to boost the life in the soil; numerous books about permaculture-related issues that are proposed to permaculture students and visitors; the drawing of the permaculture design of Permaculture Center Kamimomi; a plate filled with a diversity of food thanks to a potluck meal; the notes of the local currencies in Transition Town Fujino; and finally, the day permaculture students shared the rice they had learned to grow and harvested during the year.

5. Conclusion: From agricultural lifestyles to the political co-creation of a sustainable culture

In this paper, I showed how the concept of concrete utopia can be mobilized into a useful framework to think about the complex relation between the system in place and the need to accelerate the transition towards a sustainable society. It also sheds new light on the tension between independence and interdependence, i.e., the need and willingness to imagine and create alternative worlds in reaction to, but *within*, the current – unsustainable – system. The concept of concrete utopia implies a dilemma in terms of permaculture's future development and embeddedness within transition pathways.

Along the independence axis, we have a multiplicity of instances of "utopian sustainability," in the form of perfectly sustainable micro-scale projects being

developed within the interstices of capitalism itself. They are self-consistent and, in this sense, exemplary – but here is the first horn of the dilemma: How are they to be scaled up? Do we do it through education, or do we wait for either revolution or collapse? Along the interdependence axis, we have "sustainable concretization," in the form of larger-scale projects at the territorial level, with a political vision. These are urgently needed in order to coordinate and render mutually compatible the multiplicity of micro-projects – but here is the second horn of the dilemma: *How are they to be scaled up? Can we count on democratic processes and on collaboration with territorial authorities?*

For future research, the ideas set out in this paper point towards the need for a model and a set of practices that will link prefigurative actions with transition pathways. We somehow need to progress towards a "political and territorial permaculture project," probably at the Prefecture or Municipality level.

Acknowledgements

I would like to give special thanks to all the Japanese permaculturists who offered me time, kindness, and hospitality, among whom Shidara Kiyokazu (Permaculture Center Japan), Kyle Holzhueter and Jimoto Kazuko (Permaculture Kamimomi), Phil Honda Cashman (Permaculture Awa), Hamish Murphy (Stonebridge Permaculture), Sawyer Kai and Kawamura Wakana (Tokyo Urban Permaculture), Yuki Mitsukuri (The Permaculture Institute, Sapporo), Usui Kenji and Tomoko (Shanti-Kuthi), the Saihate Ecovillage, Yotsui Shinji and Chisato (Soil Design) and the staff of Kurkkufields, and finally Gokaichi Yasuyuki.

I would like also to acknowledge the valuable comments I received from my supervisor, Prof. Christian Arnsperger, and my co-supervisor, Dr. Yoann Moreau. I am also very grateful to Prof. Usami Makoto, Prof. Horita Makiko and Prof. Itonaga Koji. Last but not least, I want to express my gratitude to the Swiss National Fund for Research for granting me a seven-month doctoral mobility scholarship to visit Kyoto University's Global Environmental Policy Laboratory.

References

Arnsperger, C. (2009). *Ethique de l'existence post-capitaliste : Pour un militantisme existentiel*. Paris : Editions du Cerf.

Arnsperger, A. (2019). Serons-nous enfin, un jour, indigènes? Permaculture et éducation des profondeurs. In N. Wallenhorst et J.-Ph. Pierron (Eds.), *Éduquer en Anthropocène*, Lormont: Editions Bord de L'Eau, dans coll. En Anthropocène.

Berque, A. (2015). *La perception du milieu Nippon au prisme du Haïku.* La Maison de la poésie de Nantes: Poésies et écologies.

Centemeri, L. (2017). Health and the environment in ecological transition: the case of the permaculture movement. In F. Bretelle-Establet, M. Gaille & M. Katouzian-Safadi (Eds.), *The Relationship between Environment, Health, and Disease Toward a Multi-Spatial and Historical Approach,* Springer.

Centemeri, L. (2019). *Permaculture ou l'art de réhabiter*. Versailles: Editions Quae, coll. "Sciences en question".

Chakroun L. et Linder D. (2018). Le milieu permaculturel comme foyer d'émergence d'un soi mésologique. In M. Augendre, J.-P. Llored, et Y. Nussaume (Eds.), *La mésologie, un autre paradigme pour l'anthropocène ?* (pp.283-291). Paris, Hermann.

Chan, J. (Ed.) (2008). *Another Japan is Possible: New Social Movements and Global Citizenship Education*. Stanford: University Press.

Chiavacci, D. & Obinger, J. (2018). Towards a New Protest Cycle in Contemporary Japan? The Resurgence of Social Movements and Confrontational Political Activism in Historical Perspective. In D. Chiavacci & J. Obinger (Eds.), *Social Movements and Political Activism in Contemporary Japan*: *Re-emerging from Invisibility* (pp.1-23). London: Routledge.

Dinerstein, A.C. (2012). Interstitial revolution: On the explosive fusion of negativity and hope, *Capital & Class,* 36(3), 513-532.

Dinerstein, A.C. (2016). Denaturalizing Society. Concrete Utopia and the prefigurative critique of political economy. In A.C. Dinerstein, A.C. (Ed.), *Social Sciences for Other Politics. Women theorizing Without Parachutes* (pp.49-64). Palgrave Macmillan.

Dreiling, M., Lougee, N. & Nakamura, T. (2015). After Fukushima: The Silence of Environmental Organizations on Nuclear Catastrophe, *Metropolitics.* http://www.metropolitiques.eu/After-Fukushima-The-Silence-of.html

Dugua, B. & Chakroun, L. (2019). Planifier avec le territoire : la dynamique des lieux de projets à l'épreuve des approches participatives et paysagères, *VertigO- La Revue en ligne pour l'environnement.*

Ferguson, R. & Lovell, S. (2014) Permaculture for agroecology: design, movement, practice and worldview. A review, *Agronomy for Sustainable Development,* 34(2), 251-274.

Ferguson, R. & Lovell, S. (2015) Grassroots engagement with transition to sustainability: diversity and modes of participation in the international permaculture movement, *Ecology & Society,* 20(4), 39.

Ferguson, R. & Lovell, S. (2017). Livelihoods and production diversity on U.S. permaculture farms, *Agroecology and Sustainable Food Systems,* 41(6).

Grinberg, S. M. & Machado, M. L. (2018). School in the (im)possibility of future: Utopia and its territorialities, *Educational Philosophy and Theory*. http://doi.org/10.1080/0031857.2018.1485014

Hage, G. (2015). Alter-politics: Critical Anthropology and the Radical Imagination. Melbourne: University Press.

Harvey, D. (2000). *Spaces of Hope.* Edinburgh University Press.

Hathaway, M. (2016). Agroecology and permaculture: addressing key ecological problems by rethinking and redesigning agricultural systems, *Journal of Environmental Studies and Sciences,* 6(2), 239-250.

Holmgren, D. (2002). *Permaculture: Principles & Pathways Beyond Sustainability*. Holmgren Design Services.

Holmgren, D. (2004). *Permaculture in Japan: Foreign import or indigenous design?* Holmgren Design Services.

Itonaga, K., Shidara, K. & Konuma, M. (1996). *Permaculture in Japan: Suitable for the Natural and Cultural Conditions of Japan.* Proceedings of the Sixth International Conference, Perth: Australia.

Léger, F., Morel, K., Bellec-Gauche, A., Warlop, F. (2018). Agroforestry market gardening: a strategic choice to improve sustainability in agroecological transition? *International Journal of Agricultural Extension*, 6, 43-52.

Lockyer, J. & Veteto, J.R. (Eds.) (2015). *Environmental Anthropology Engaging Ecotopia. Bioregionalism, Permaculture, an Ecovillages*. New York and Oxford: Berghahn.

Mollison, B. & Holmgren, D. (1978). *Permaculture One: A Perennial Agricultural System for Human Settlements*. Melbourne: Corgi.

Morel, K., Léger, F. & Ferguson, R.S. (2018). Permaculture. In B.D. Fath (Ed.), *Encyclopedia of Ecology, (2nd ed.).* https://doi.org/10.1016/B978-0-12-409548-9.10598-6

Münster, A. (2013). *Utopies, Écologie, Écosocialisme. De l'utopie concrète d'Ernst Bloch à l'écologie socialiste.* Paris: L'Harmattan.

Ogawa, A. (2016). Japan's awakening protest movement, *Asian Studies Association of Australia* [online] http://asaa.asn.au/japans-awakening-protest-movement/

Oguma, E. (2016). A New wave Against the Rock: New social movements in Japan since the Fukushima nuclear meltdown, *The Asia-Pacific Journal,* vol. 14 (13), 2. https://apjjf.org/2016/13/Oguma.html

Paull, J. (2011). The making of an agricultural classic: farmers of forty centuries or permanent agriculture in China, Korea and Japan, 1911-2011, *Agricultural Science,* 2(3), 175-180.

Pignier, N. (2017). *Le Design et le Vivant. Cultures, agricultures et milieux paysagers.* Saint-Denis: Editions Connaissances et Savoirs.

Puig de la Bellacasa, M. (2012). 'Nothing comes without its world': Thinking with care, *The Sociolological Review* 60: 2.

Roux-Rosier, A., Azambuja, R. & Islam, G. (2018). Alternative visions: Permaculture as imaginaries of the Anthropocene, *Organization,* 25(4), 550–572.

Wright, E.O. (2013). Transforming Capitalism through Real Utopias, *American Sociological Review* 78, 1-15.

The International Academic Forum (IAFOR)
Sakae 1-16-26-201
Naka Ward, Nagoya, Aichi
Japan 460-0008
ww.iafor.org