

OFFICIAL CONFERENCE PROCEEDINGS

ACSEE 2021

November 01 –02, 2021 | Online from Tokyo, Japan

ISSN: 2186-2311

The 11th Asian Conference
on Sustainability, Energy
& the Environment

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

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The Asian Conference on Sustainability, Energy & the Environment 2021

Official Conference Proceedings

ISSN: 2186-2311



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The International Academic Forum (IAFOR)
Sakae 1-16-26-201
Naka Ward, Nagoya, Aichi
Japan 460-0008
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Rural Culture Preservation in Rural Tourism Development in Suburban Villages of Large Cities in China: Case Studies of Nanjing

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The Asian Conference on Sustainability, Energy & the Environment 2021
Official Conference Proceedings

Abstract

In the context of rapid urbanization, many suburban villages in China have started the tourism-orient transformation by virtue of supporting policies and individual advantages. However, rural cultural decline under disruption and ignorance has become a major pressing issue limiting the rural tourism development and the urban-rural integration process. Recently, scholars and practitioners have drawn attention to the protection, conservation and revitalization of rural culture in tourism development. This research explores the protection and inheritance of rural culture in tourism transformation practices of suburban villages in large cities of China through qualitative and quantitative analysis derived from investigation of 17 culture-featured villages in suburbs of Nanjing, Jiangsu, China. The article identifies the changing patterns in demand and shifts in the attitudes toward rural culture during the rural tourism development through literature review and interviews. Rural culture protecting and promoting strategies are summarized, including culture-related industry introduction, rurality and characteristic highlighting and the collaboration of urban-rural operators. Further, real-time visiting numbers of the investigated villages are extracted from a local service platform (Nanjing Beautiful Countryside Big Data Service Platform) 5 times a day for a month to serve as an indicator of popularity, while comments and ratings from the tourists are aggregated from field interviews and major travel websites. The statistics confirm the influence of rural cultural elements on rural tourism satisfaction. Finally, the article points out the shortcomings in culture construction in the current rural tourism transformation and proposes a discussion on the authenticity of rural culture.

Keywords: Rural Culture, Suburban Villages, Tourism Transformation

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1. Introduction and Literature Review

China has seen an explosive rate of urbanization from 19.39% in 1980 to 60.6% in the end of 2020 (Figure 1, National Bureau of Statistics, 2021). Rapid urbanization has consumed its agricultural hinterlands, and profoundly impacts the economic, social and culture context of surrounding rural areas. Economic impact, technological improvement and government policies has deepened the central cities' penetration into and control of suburbs, leading to continuous outflows of population, rural land desolation and rural ideology breakdown in suburban rural area (Zhou & Ma, 2000; Zhang et al., 2016; Liu & Wang, 2018). Accompanying this trend is the collapse of rural culture. The patterned construction of rural residents has erased local feature, while the dilapidation and destroy of historic sites in rural areas under urbanization is commonly seen. Rural custom and lifestyle, being part of rural culture, are disappearing with the population loss as well.

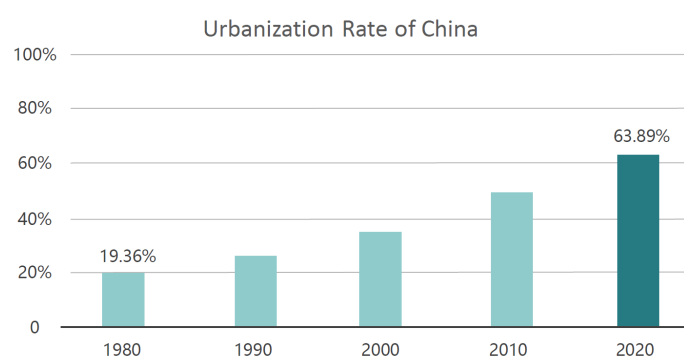


Figure 1: Urbanization Rate of China.

Rural tourism has been considered as a practical way to revitalize the decaying rural area for the last two decades in China with reference to both native and international lessons. However, the introduction of tourism runs the risk of accelerating the demise of local rural culture. Academics claim that rural renewal under urban dominance is actually distortion of rural values, leads to the disappearance of rural cultural space and changes in functions, which eventually accelerates the extinction of traditional rural culture as well as in-situ cultural scape (Huang & Huang, 2018).

The dilemma has drawn academics and practitioners' attention to rural culture in the context of rural tourism development. Many researchers have discussed the concept, advantages and preservation methods through practices and case studies, showing constantly concerns for rural culture disruption in tourism development (Liu & Yu, 2012; He, 2004; You et al., 2012). Huang & Huang (2018) conducted a comprehensive and detailed review of rural culture research under urbanization and tourism development. By reviewing rural culture related researches, the article focuses on the influence and effectiveness of tourism development on rural culture, the practical method in rural culture preservation or utilization, etc., presenting ideas, directions and main scientific issues for rural culture conservation and reconstruction for future researches.

However, current studies mainly focus on villages with special cultural backgrounds or historical endowments, little attention has been paid to suburban villages, which have been greatly influenced by urbanization. While tangible and intangible culture of ancient villages in hinterland might be preserved due to separation from city center, customs and historic relics of suburban villages are disappearing even before people realizing their value.

Nevertheless, it is impossible and pointless to completely maintain suburban rural areas, the insist of original rural form and lifestyle is just a fantasy.

In fact, many designers have given their answers on rural culture preservation and promotion in tourism transformation practices in China. However, there is still a lack of systematic research in existing studies. This study aims to take fill this gap through a case study of Nanjing in Jiangsu Province. Rural tourism development history in suburban villages are reviewed first with a focus on the changing attitude toward rural culture. Then, the study concludes the culture preservation and promotion strategies based on cases in Nanjing. Seventeen culture featured rural tourist spots are surveyed for current performance, with general drawbacks and rural authenticity preservation being discussed afterwards.

2. Research methods

2.1 Study area

The study was carried out in the 6 suburban districts of Nanjing, the capital city of Jiangsu Province in southeastern part of China. Nanjing has a population of 8.5 million with an urbanization rate of 83.2% at the end of 2019. The furthest district can be reached within 1.5 hour through the highway network (Figure 2).

Rural tourism in Nanjing was started at the end of last century and experienced a continuous growth especially in the last decade under a series of supporting policies. At present, rural tourism receives roughly a quarter of total number of tourists in Nanjing (Yan, 2020).

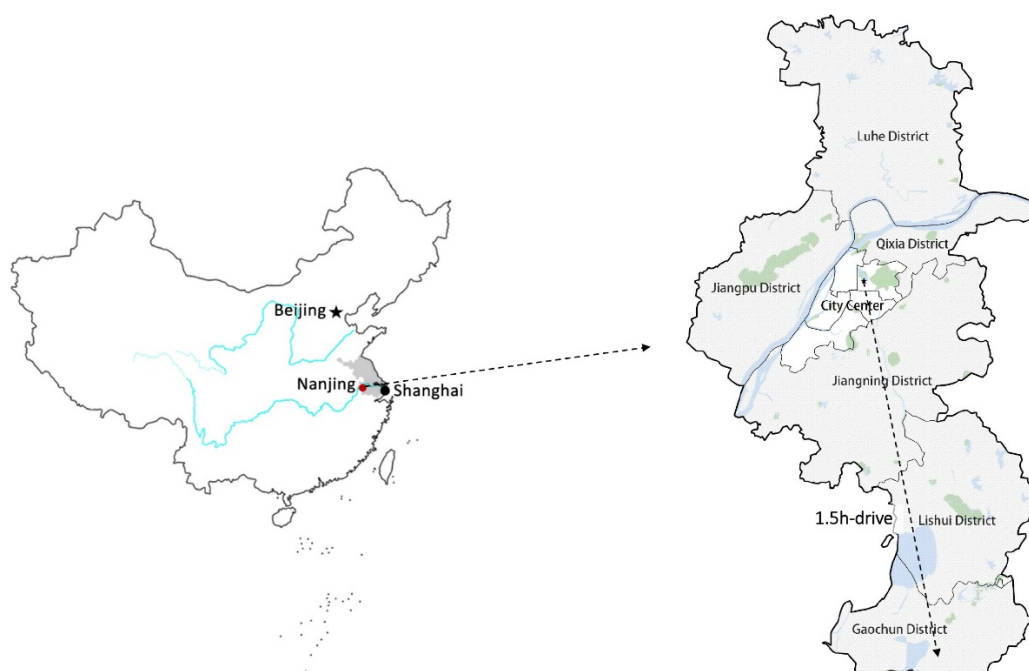


Figure 2: Location of Nanjing and municipal districts of the city.

2.2 Research design and data collecting

The research was conducted in 3 steps. Firstly, development history of rural tourism in Nanjing suburbs is investigated through statistical and archival analysis with a focus on rural culture.

Secondly, centralized field researches were carried out from October 2019 to May 2020. Rural culture presentation, architecture and landscape features, infrastructure and service level were recorded in order to sort out the culture-related strategies and problems for tourism transformation in suburban villages.

Finally, real-time visiting numbers of seventeen rural culture featured tourist spots are extracted from ‘Nanjing Rural Tourism Big Data Service Platform’, a service platform officially launched in Nanjing local service App in May, 2018 by government. The Platform provides activity information and real-time data of weather and visitor number of 63 major rural tourism spots in 6 suburban districts. Visitor number was collected 5 times a day for a month (6 May to 14 June) as an indicator of popularity. Tourists’ comments and ratings are aggregated through three popular travel websites in China (Figure 3).

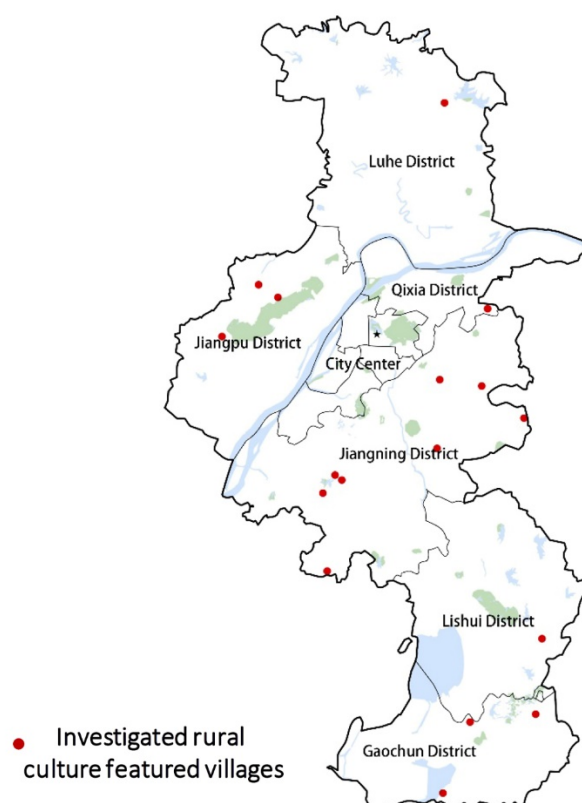


Figure 3: Location of the 17 investigated rural culture featured villages

3. Historical development of rural tourism in Nanjing suburbs

Based on the current situation, location and resources of the village while in accordance with the village’s evolutionary trends, suburban villages refer to villages located within suburban areas of the city with part or all land being statutory village planning land. Compared to traditional agriculture-dominant ones, suburban villages usually have higher economic and infrastructure level, meanwhile retain rural appearance and natural landscapes to a certain level.

Rural culture, which can be deemed as the sum of all things and phenomena created in the process of human interaction with rural nature (Zhang & Zhang, 2017), contains rural historic sites, custom and folks as well as agricultural landscape and lifestyle. These characteristics are usually emphasized as selling points in tourism. Recently, many rural tourism practices

attempt to combine traditional tourism with modern cultural industry, enriching the meaning of rural culture in the current context. Scholars claim that rural cultural tourism has become an innovative form of tourism that has injected vigor and vitality for the development (Zhao & Yu, 2015).

The historical development of suburban rural areas in Nanjing could be roughly divided into four phases in consideration of focuses, dominant forces and transformation outcomes. The attitude and related strategies towards rural culture have also changed at different stages.

3.1 The first phase, from 1990s to 2001, the spontaneous transformation

The development of rural tourism in Nanjing can be traced back to the end of last century. The budding stage is dominated by individual's spontaneous actions offering fundamental tourism product or service with rural features. The farmhouse homestay tourism is the dominant form of rural tourism in China at the early stage (Wang & Hu, 2002), which is basically household-run small business providing rural cater, accommodation and leisure activities relying on the land, house and local resources owned by farmers.

Rural culture is neglected or abandoned both in form and content. Most operators pay no attention to culture-related aspects while some others even choose to deliberately imitate foreign countryside or urban forms in farmyard redecoration, reflecting the urban-driven ideology and disdain for local rural attributes.

3.2 The second phase, from 2002 to 2010, the government promoted transformation

The emerging drawbacks of household business mode, including rural identity degradation and ecological resources abuse, posed an elevated risk for future development. Learned from domestic and international experience, the government are well-acknowledged with the potential and pitfalls in suburban rural tourism. Marked by Nanjing's Agricultural Tourism Development Plan in 2002, rural tourism began to embark on a government regulated development path (General Office of the CPC Nanjing Municipal Committee, 2008).

Rural culture gradually gained attention at this stage. Unlike household operations which kept indifference to rural culture, government promoted rural tourism project with a certain scale showed two opposing attitudes. One is to emphasize cultural characteristics in tourism for villages with special cultural assets. For example, ancient villages such as Yangliu Village have been preserved and consciously developed for tourism. Some other ones tend to highlight special cultural elements, such as the tea culture enhancement in Huanglongxian Village where tea has been grown for generations. The other attitude is to completely abandon rural elements, building urban style resorts that serve urban residents relying on excellent natural environment in countryside.

3.3 The third phase: from 2011-2016, the rapid top-down development

Suburban rural tourism has seen an improvement in service amenities and standard under the guidance of local government, while the long-standing homogeneity has led to the cooling down of the once-popular farmyard tourism. The government saw the problems and took actions under the guidance of national-level policies. In 2011, the idea of the construction of 'Beautiful Countryside' was proposed in Nanjing with pilot projects located in Jiangning District. Compare to the previous establishment of 'rural tourist spots', integration and

creation of ‘rural tourist area’ are development focus of this period.

The importance attached to rural culture has further increased due to the dilemma of homogenization. Apart from traditional rural culture emphasis methods, several villages attempted to introduce new culture-related elements into rural area. For instance, Danian Village succeeded in introducing cycling culture relying on the advantage of being the cycling venue for the 2th Youth Olympic. Some others aim to transform into theme parks with cultural elements, such as Machangshan Three Kingdoms Village. At this stage, the understanding and emphasis of rural culture is mostly reflected on physical appearance of settlements.

3.4 The fourth phase: since 2017, the collaborative development under retrospective

Rural tourism experienced rapid growth in both scale and quantity in the previous stage. New problems such as depopulation resulting from tourism-oriented gentrification are emerging, while old problems like homogeneity still remains. In 2017, the Government formally issued the *Province Characteristic Rural Areas Construction Action Plan in Jiangsu*, underlining the importance of diversification and multi-party cooperation in rural transformation.

Nowadays, there is a deeper understanding of and focus on rural culture. Unlike ‘placing cultural elements into the countryside’ in last phase, today’s practices tend to blend cultural elements with local rural characteristics of both appearance and lifestyle. On the premise of limited influence of local residents, rural tourism benefits both villagers and tourists rather than creates a purely tourist attraction. For example, the creation of Guanyin Collection in Guanyindian Village aims to combine traditional rural handicrafts with cultural creative products and modern pop-up store.

3.5 Changing attitude of rural culture in rural tourism development in Nanjing suburbs

During the whole period, we are seeing changes in leading force, construction scale and attitude towards rural culture in tourism-orient development. As the leading force changes from individual villagers to government and then to multi-party collaboration, construction scale also sees a corresponding change from household-scale business to village-scale tourism spots and then to a region-scale rural tourism network.

Accompanying the deepening understanding of rural culture is the richness of rural culture emphasis in rural tourism development. In terms of physical appearance, rural culture highlighting methods evaluate from tourism village template construction to in-situ rural style preservation. Tourism activities have also enriched from mere cultural heritage tour or folk-art experience to the full immersion rural lifestyle nowadays.

4. Rural culture preservation and promotion strategies for suburban villages in tourism adaption

General strategies responding to culture preservation and promotion could be extracted from practices in Nanjing in terms of industry transformation, spatial renewal as well as operation. Proper culture-related industry introduction is the basis of tourism transformation. Overall look integration, architecture and landscape design and application of materials and structures correspond to appearance renewal at different scales, while the multi-party construction and

maintenance are invisible factors of outcomes (Figure 4).

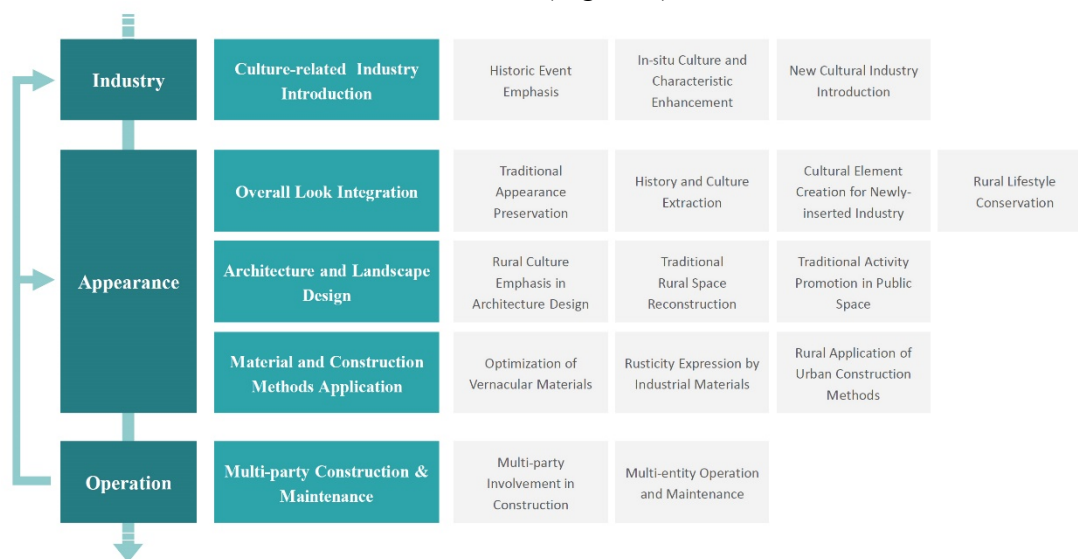


Figure 4: Outline of Rural culture preservation and promotion strategies

4.1 Culture-related industry introduction

Past experience confirmed that reckless copy of cultural elements in appearance hardly brings success but homogeneity and vicious competition in tourism development, rural culture should never be adopted as a decorative element but a core feature unifying industry and appearance. In practices, historical event emphasis, in-situ culture and characteristic enhancement and new culture-related industry introduction are major ways for tourism industry introducing and upgrading based on villages’ own endowments.

Historical event emphasis is a common choice for villages with historical resources for in-depth exploration of tourism. Some other villages have succeeded in enhancing their own cultural assets. For example, Huanglongxian Village in Jiangning District managed to upgrade traditional agricultural industry and blend tea culture into tourism. Besides, new culture-related industries that fulfill the need of urban dwellers are also chosen by some villages with promising outcomes recently. Unlike several years ago when urban space and ideology eroded into countryside, today’s new culture-related industry mostly succeeded in achieving the integration and co-development with original rural culture.

4.2 Rural culture emphasis in appearance

Being the most distinctive feature in rural areas, physical appearance shows irresistible attraction to urban dwellers tired of dull urban environment. Appearance related strategies are most preliminary and effective in rural culture preservation and promotion, which can be confirmed by both literature and researched comments.

The overall appearance of the village leaves a first impression on visitors. Learnt from previous dilemma that rural customs and culture are impossible to be appreciated with different architectural styles mingled in one village, overall appearance integration has become first step in village-based tourism development. Traditional appearance preservation, history and culture extraction, environment creation for newly-inserted cultural industry and rural lifestyle conservation are common strategies for culture emphasis. Pitifully, although majority of the investigated villages follow or show respect to original rural look, there are

still several projects choosing to completely abandon original feature, becoming replicas of precedents.

Then it comes to culture presentation in architecture and landscape design. This process is usually undertaken by planners and architects, whose strategies can be summarized as historical and cultural highlight in architecture, traditional rural space reconstruction and traditional activity promotion in public space. These methods are often used simultaneously in projects. Take Huashu Village as an instance, the designer attempts to reshape the specific public space – village entrance by renovating an old farmhouse and surrounding area. As the architect pointed out, ‘In traditional Chinese villages, the entrance is an important public node, serving as a demarcation point between the settlement and nature, with the functions of marking and separating, traffic organizing and leisure gathering (Zhou & Yin, 2017).’ Rural culture and lifestyle are underscored with traditional layout and architecture style, reshaping the village entrance to be a symbol of village, a place for public activities and a collection of local memory.

Finally, material application and construction methods are also unignorable in culture and rurality emphasis. Traditional vernacular forms and materials are inherited from generations of craftsmen, containing the knowledge and response to specific climate, topography, and resources, being part of rural history and culture. Nevertheless, the limitations of rural materials and construction methods including high expense and poor duration are unmissable currently. Nowadays, designers try to combine rural culture with the urban way of construction, striving to preserve the rural flavor and traditional memories while meet the ascending demand of residents and tourists. In actual practices, the new use of vernacular materials, rurality expression by modern material and rural application of modern construction realize the combination of rural culture preservation and modern function demands in current architecture design.

4.3 Multi-party construction & maintenance

Many suburban villages were reconstructed under the impetus of government and capital, flourished for a while and then declined without achieving sustainable development of the newly-inserted rural industries. These disappointing cases are strongly attributed to insufficient acknowledge of villages’ reality and disconnection between decision makers and actual users. Nowadays, the government, entrepreneurs and designers have all been aware of the importance of multi-partnership in both construction and operation period. The cooperation ensures the practical needs of actual users and enhances the sense of participation and honor in village development, greatly improving the sustainability of rural tourism.

The tourism-oriented transformation of suburban villages is not a one-shot deal but a long-lasting project requiring continuous operation and maintenance. As material basis, farmhouse decoration and environment improvement cannot guarantee the profit of tourism. Nowadays, a relatively mature rural tourism development model is commonly seen in Nanjing suburbs with the combination of ‘top-down’ construction led by government and ‘bottom-up’ operation led by individual participants. As a result, original villagers are able to have a voice and share the dividends in tourism transformation, new residents in the village could enjoy urban level living standard. With advantage in capital and operation compared to villagers and flexibility compared to government, the attendance of social enterprises can enhance the tourism sustainability to some extent.

5. The current status of culture featured rural tourism in Nanjing suburbs

5.1 Construction time of rural culture featured tourism villages

The shift of the importance of rural culture can be perceived in tourism development history. In the first stage, tourism operators basically paid no attention to rural culture. In the second stage, rural culture was mentioned in tourism introduction especially in top-down projects, but there were few rural culture focused ones. Along with the rapid development of rural tourism, rural culture also became one of the selling points of tourism in the third stage. In the fourth stage, which focuses on characteristic development, the proportion of rural culture featured villages sees a continuous increase with subtler highlights and richer tourism products (Figure 5).

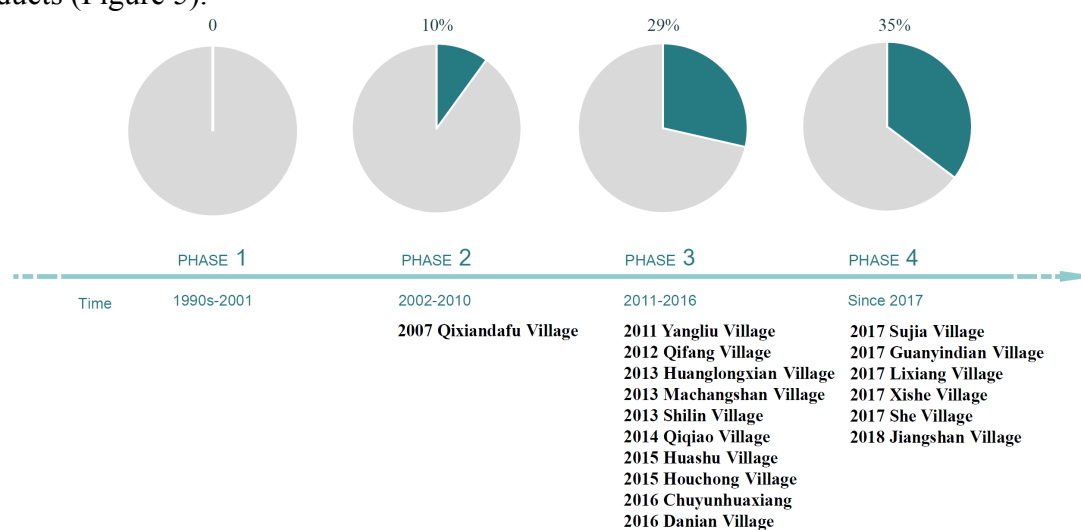


Figure 5: Construction time of rural culture featured tourism villages

5.2 Focuses of rural culture featured tourism village

Referring to the status quo, the 17 investigated rural culture tourism spots can be roughly classified into 4 categories according to attributes and culture emphasis methods. The first and most common type is historical event emphasis ones (35%), extracting cultural elements from a certain period of time or event. Then it comes to the cultural focus on local endowment highlight (24%) and new culture-related feature introduction (24%), with the aim of unique cultural characteristics presentation or new cultural properties insertion. The last one is historic sites preservation in particular villages with long history (17%), preserving the authenticity in both form and lifestyle as much as possible.

It is important to note that most of the suburban villages have two or more focuses mentioned above. For example, though Guanyindian Village in Jiangning District features in local handicrafts and folklore display, cultural creative industry and B&B business are also indispensable parts. In this research, the 17 targeted villages are categorized by their main focus.

5.3 Distribution of major culture-featured tourism spots

Investigated rural tourist spots are dispersed in all 6 suburban districts of Nanjing. Nearly half of them are located in Jiangning District with a most even distribution, while others are dispersed near natural attractions (Figure 6). There is not an obvious agglomeration of the

seventeen villages. Two relatively gathered area are around Laoshan Area and Yinxing Lake area, both of which are the earliest rural tourism development areas with relatively mature economic foundation.

Compare to other types of villages (Leisure and Sightseeing, Agricultural Experience, Featured Tourism Spot, Agricultural Technology), economic conditions have greater impact on rural culture featured ones as they require certain investment and scale as well as resource endowments. This may more or less explain why Jiangning District owns most rural culture villages since it has the highest economic level.

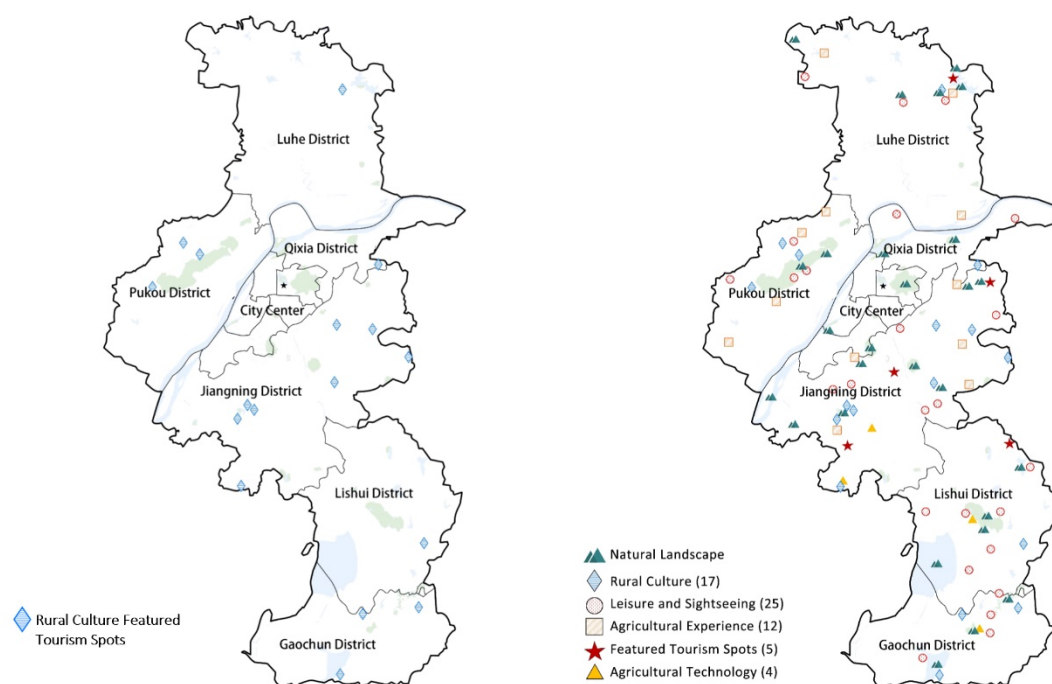


Figure 6: Distribution of culture-featured tourism spots and comparison with other categories

5.4 Temporal distribution of visitor number

The visiting number shows significant difference between working days and holidays. Specifically, weekends receive roughly twice the number of daily visitors during workdays (Figure 7). Calculated by kernel density analysis with the help of Arcgis 10.4, the heatmap of visitor numbers illustrates that rural tourist attractions receive most visitors at noon in both no in both weekdays and holidays since most urban dwellers opt for one-day trip to suburban villages which are usually 1-2 hour drive away (Figure 8). Pitifully, there are few visitors choose to stay overnight in culture featured ones although many villages are actively promoting their B&B business. Referring to individual villages, most of them are in similar situation yet some spots see a visiting peak at special events, and some others are in long-term slump. There is no clear difference among various culture focuses in visiting number (Figure 9).

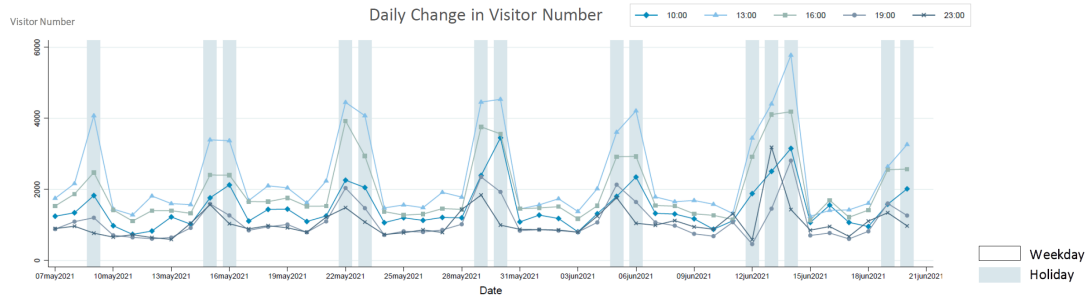


Figure 7: Daily and temporal change of visitor number

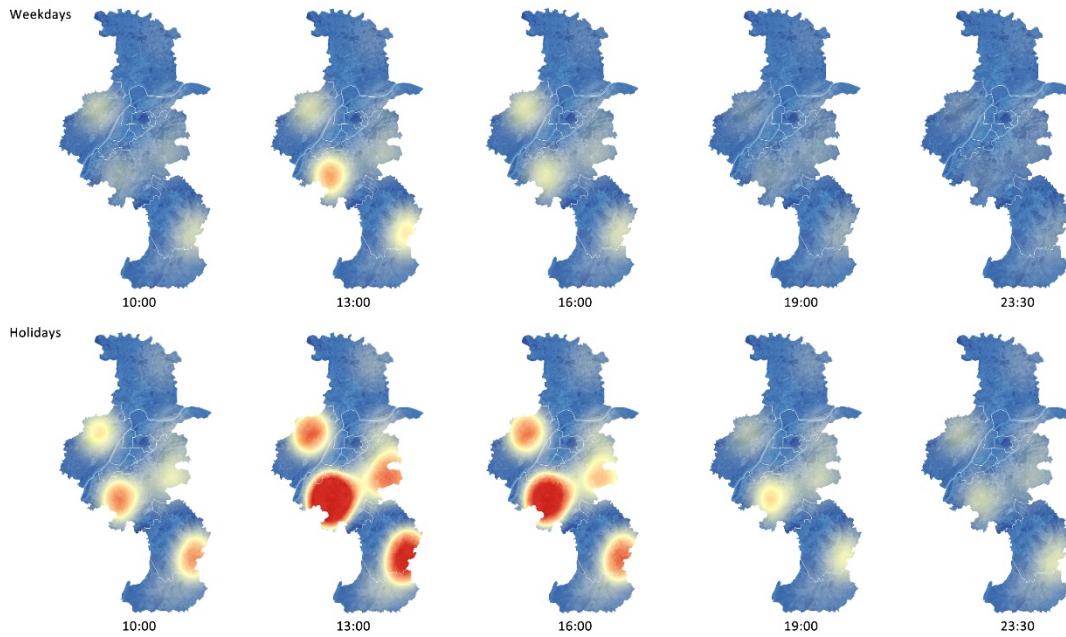


Figure 8: Heatmaps of culture featured tourism spots popularity

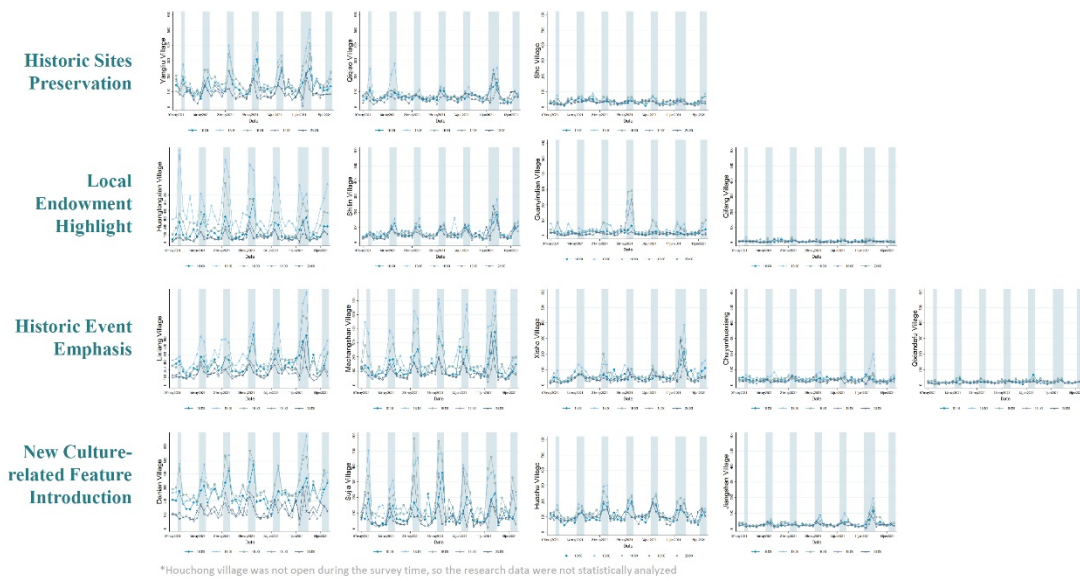


Figure 9: Daily and temporal distribution of visitor number of individual villages

In terms of geographical distribution, there is a high overlap of heatmaps of rural culture featured villages and all 63 observed rural tourism spots, which confirms that currently

villages highlighting rural culture still relies on mature rural tourism areas to some extent (Figure 10). It is worth mentioning the thriving trend of Lixiang Village, a tourist spot with excellent cultural emphasis, facility service and settlement renovation in transformation. The village have welcomed many visitors since officially opened in 2017 and received quite good comments. At present, the village have gradually driven the revitalization of surround area.

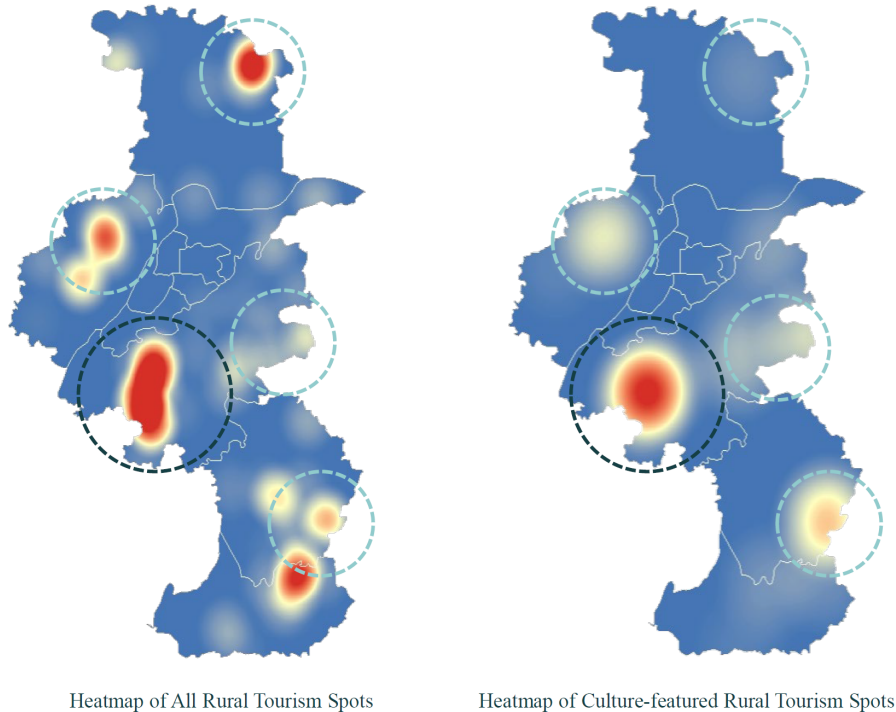


Figure 10: Heatmaps of rural culture featured villages

5.5 Tourist evaluation and rating

According to field interviews and ratings from travel websites, most of the tourists are satisfied with the culture featured tourist villages in Nanjing (Figure 11). Visitors’ comments mostly focus on service and infrastructure, natural scenery, settlement environment, culture-related elements, activity richness, architecture and landscape as well as agricultural scenery. Among those, service, natural scenery, settlement environment and culture-related elements receive similar attention, being mentioned in half of the comments (Figure 12).

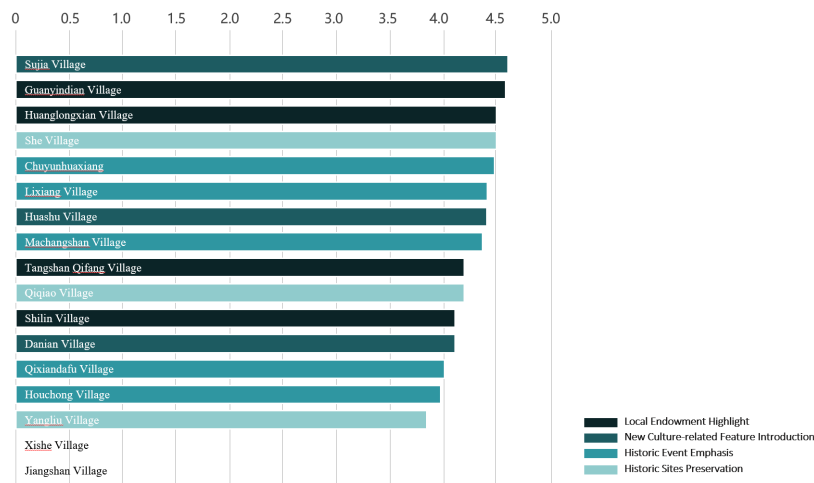


Figure 11: Ratings of culture featured rural tourism spots

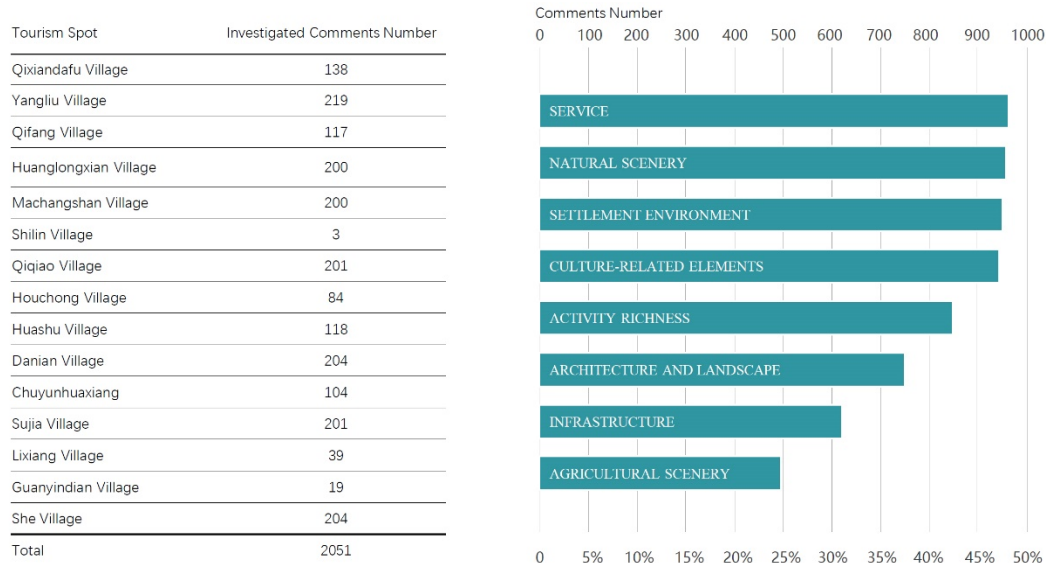


Figure 12: Visitor comments focuses

Common attributes can be found in villages with high rate, including improved infrastructure and facilities, clear selling points and accurate positioning. Meanwhile, some villages receive relatively low ratings and comments. Nearly 90 percent of poor reviews focus on infrastructure, service and activity richness, showing the most basic demand of travelers for rural tourism (Figure 13). In fact, culture emphasis or architecture design can hardly improve the tourism outcomes once those basic demands cannot be met.

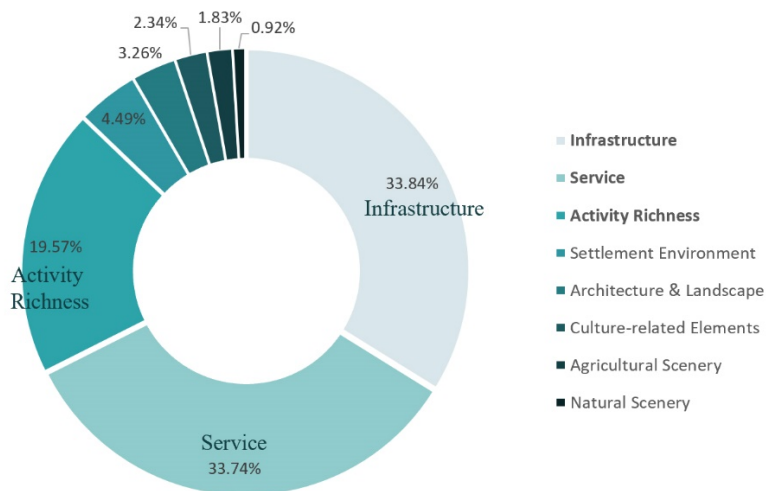


Figure 13: Focuses of Poor Reviews and Suggestions

It is possible to outline the common problems in current practices by analyzing poor reviews and villages with unsatisfying performance. The first and most obvious problem is the poor infrastructure and service level which seriously affect visitors’ attitude towards rural tourism. Interviews show that some visitors disappointed by low-level tourism experience express their contempt for rural area and culture, claiming those to be just dilapidated with no worth for appreciation and preservation. Secondly, it is a pity to point out that rural culture is just a gimmick rather than focus in some villages, which means the core of those villages is still the outdated farmyard experience, showing little competitiveness to other categories. Finally, the misalignment between envisioned orientation and status quo strongly limits the development.

For instance, several projects put too much efforts on specific building reconstruction, yet without sufficient supporting facilities and services, it is hard to attract the public with only concepts or a single building.

6. Discussions and Conclusion

6.1 Rural authenticity preservation in tourism introduction

The ‘authenticity’ of countryside has always been a topic in rural renovation especially in actual renewal projects. On one hand, its importance cannot be denied as it carries not only the history and culture but also residents’ memory and faith. On the other hand, as the dominance of agricultural production in the suburban villages of large cities has disappeared, countryside can no longer and has no need to take on the role of agricultural production for the central city. With rural land and traditional value under tremendous impact, it is almost impossible stop the continuing decline of suburban rural areas even with top-down regulations.

Many scholars have criticized that tourism development may do some harm to rural authenticity. However, at present, the unsatisfying living condition and insufficient employment are further accelerating the depopulation and decline of suburban villages. The decaying suburban villages, though many of which are historically or culturally valuable to preserve, are disappearing under urbanization even before people realized their value, not to mention conscious rural authenticity preservation.

The introduction of rural tourism is a tested way for rural revitalization worldwide. Providing new economic growth points, reasonable rural tourism development can help rural population return and raise people’s awareness of rural history and culture, which eventually benefit the preservation of rural authenticity. Lixiang Village is an excellent example for a hollow-out village revitalizing through tourism introduction. Though being an important historic site for War of Resistance against Japan, Lixiang was not free from hollowing out and ageing. With tourism introduction started in 2016 focusing on cultural theme blending with original rural lifestyle, Lixiang has gradually come out of the status quo of desolation and depression, becoming a new tourism spot and an educational area.

In recognition of the significance of rural tourism development, considerable attention should be addressed to balance between the corresponding promotion and interruption. Tourism development which completely disregards rural authenticity can hardly result in satisfactory outcome hence they are usually unable to meet the images and demands of visitors who are attracted by rurality and authenticity. However, it is also impossible and senseless to completely maintain the original village appearance in tourism development in today’s China especially in suburbs of large cities. Sometimes the reckless insist of rural authenticity conservation may lead to pitfalls that limit the further development or cause original villagers to abandon their home since their basic needs are restricted. Though the original buildings might be preserved through this way, rural authenticity is somewhat disappearing as the customs, folks and lifestyle are lost along with the loss of native residents.

In actual tourism transformation practices, two phenomena that do more or less harm to rural authenticity should be alerted. First one is the mis-understanding and mis-adoption of rural culture. In general sense, rural culture excavation is helpful for culture heritage and rural authenticity preservation. However, ‘cultural’ symbols are blindly installed into some villages

to create cultural or historic theme parks. Still centered on basic tourism products, these projects are actually a great destruction of the authenticity of countryside and are also difficult to be economically successful.

The second problem are reflected in comments especially the negative ones. Although urban tourists are showing increasing interest on rural culture, architecture and landscape design in rural trips, the fundamental demands of tourism are still the first criteria. When these basic requirements, for instance, service, facility or activity richness, are not met, tourists are unwilling and unable to enjoy the rest assets, which greatly limits the in-depth and high-level development of tourism. What makes things worse, as public's attitude towards countryside remains to be 'poor, dirty and boring', the meaning and value of rurality and culture preservation cannot be acknowledged by the public especially in suburbs, hence rurality authenticity preservation will be half the effort.

To sum up, the preservation of rural authenticity in tourism introduction calls for a careful balance. Rurality preservation in physical appearance is essential, yet urban-standard facilities and services is the guarantee of tourism and other industry development. Finally, a well-established public participation mechanism is the invisible factor to ensure the sustainability of tourism, preserving the non-physical components of rural authenticity.

6.2 Conclusion and Limitations

By analyzing the history and current situation of tourism villages in Nanjing suburbs, this paper provides a more comprehensive review of culture preservation and promotion in tourism development. Strategies in terms of culture-related industry introduction, rural culture emphasis in appearance and multi-partnership management have been commonly acknowledged in current practices as useful way to preserve and promote rural culture. Infrastructure and service level, settlement environment and culture-related elements strongly affect the visitors' satisfaction and preference for rural culture featured tourist villages.

There are also some limitations calling for further and finer researches. The relatively concentrated observations might lead to ignorance of seasonal and holiday changes, and the Covid-19 epidemic and related policies may lead to accidental comments. Further researches could be focuses on the differences and underlying reasons for culture-featured tourism villages and other categories of rural tourism attractions with respects of distribution, performance and specific transformation strategies.

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Research on Intensive Development Mechanism of Land Use in Small and Medium-sized Cities in Western China Based on “the Yangtze River Conservation” Strategy

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The Asian Conference on Sustainability, Energy & the Environment 2021
Official Conference Proceedings

Abstract

As a crucial national strategy of China’s national ecological civilization construction, “the Yangtze River Conservation” aims to achieve the overall planning and balance of ecological protection and urban spatial development at the macro-scale of the entire river basin. In practice, there are significant differences among cities along the Yangtze River. Different from the central large cities which have concentrated resources, technology and human resources, small and medium-sized cities are limited by their resources, location and underdeveloped economic level. Therefore, differentiated and intensive urban spatial structure and land use mechanisms will be of great significance to sustainable urban construction in the future. In this research, eight small and medium-sized waterfront cities in Chongqing were detailed investigated, revealing the dynamic spatial-temporal relationship between urban space, water and citizen life in history, which can be summarized into four types of urban spatial structure evolution models. Based on this, a five-part intensive land use framework consisting of evaluation, accounting, grading, resilience, and collaboration is proposed for architectural design. Firstly, the ecological sensitivity of built-up areas is evaluated as the basis. Secondly, functional indicators are accounted for and construction capacity is readjusted to avoid extensive land expansion. Then, the construction proposal is graded in terms of efficiency of use, which will be gradually realized in multiple stages to improve risk resistance. Finally, a land information platform is established before construction sharing between neighboring blocks to achieve resource complementarity.

Keywords: Intensive Development, Land Use Mechanism, Western China, Small and Medium-Sized City, The Yangtze River Conservation

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Introduction

China has experienced rapid urbanization in the last three decades, and the results of the seventh national census in 2021 show that the current urbanization level in China has jumped from 17.92% in 1987 to 63.89%, and the total population living in urban areas has also broken through from 170 million to 900 million, with the number of mega-cities and super-cities increasing to 7 and 14 respectively, making considerable achievements in urbanization construction. And these results are particularly prominent in the development history of cities in western China.

From the end of the 20th century to the present, the development of western Chinese cities has gone through several periods in which it has been closely related to the introduction and implementation of several national policies or strategies. The cities in western China are widely distributed and numerous, including 12 provinces, municipalities or autonomous regions, accounting for 71.4% of the country's area and 27.12% of the population in 2020, and it is difficult to analyze them one by one, so Chongqing, which plays an important role in several national policies and strategies, is selected as the regional boundary for this study.

Chongqing is located in the southwest region of China, and as a provincial administrative unit, is the youngest of the four major municipalities in China. After becoming a municipality in 1997, it has been constantly present in China's national development strategies. In "China's Western Development Drive" strategy, which started in 2000 and continues to this day, Chongqing is one of the important development pivots connecting the more economically developed coastal areas in the east and the vast areas in the less developed west. In 2013, the "One Belt, One Road" cross-border cooperation began, and Chongqing gradually formed a "diamond-shaped" interaction with Chengdu in the west, Kunming in the south and Xi'an in the north, becoming an important economic opening node together and making great progress in the construction of western cities. In 2016, "the Yangtze River Conservation" strategy was proposed to develop the Yangtze River Economic Belt, which aims to "step up stronger conservation and stop its overdevelopment", so the balance between economic development and ecological conservation is further emphasized. As can be seen from the map, Chongqing is an important urban node in the upper reaches of the Yangtze River and has a key role in controlling water quality, coordinating transportation and protecting the ecosystem of the river basin.



Figure 1: Chongqing in Western China and the Yangtze River Basin

After the implementation of this series of initiatives in recent years, western cities, including Chongqing, have made great progress in economy, living standards and urban construction. However, in the process of rapid urban spatial expansion, various problems and challenges have gradually emerged and can be sorted into three main aspects in terms of urban land use.

The first is about ecological pressure: The Yangtze River conservation strategy puts higher demands on economic development based on environmental protection. Secondly, the development goal of China has transformed from a single pursuit of speed to high-quality sustainable development, so intensive use of urban land is imperative. The third aspect is how to face imbalance. The Yangtze River Economic Zone spans 11 provincial-level administrative regions, and the geographical climate, economic level and development status vary significantly between different regions. In addition to the well-known economic development gap between eastern and western cities, the uneven development between western cities, especially between large central cities and small or medium-sized cities, is further intensifying, and this is often downplayed in the formulation of urban development and land use plans.

These imbalances can be clearly reflected in the population growth data for each part of Chongqing. From 2010 to 2020, the population of large central cities continues to gather, with a rise of nearly 30%, yet most small and medium-sized cities lose population severely, ranging from about -1% to -10%. In terms of urban spatial perception, the contrast between the two is even stronger. Decaying old streets, broken old city spaces, and halted construction projects in new development zones reflect the current situation of spatial structure fragmentation and extensive development of land resources in small and medium-sized cities.



Figure 2: Contrasts between Large Central City and Small or Medium-sized Cities

In summary, discussing intensive land use mechanisms in western Chinese cities in the current context is an important research proposition, and this study attempts to discuss spatial development of small and medium-sized cities along the Yangtze River in Chongqing from two clues: parallel comparison between cases and the spatial evolution of a typical city in history.

Parallel Analysis: Eight City Cases

China's city size classification standard is based on urban resident population, and cities are divided into five major categories with seven subcategories: mega-city, super-city, type I large city, type II large city, medium-sized city, type I small city and type II small city. On this basis, we conducted an overall sorting of cities in Chongqing using the 2020 statistics of Chongqing and divided cities in Chongqing into one mega-city, one large city, seven medium-sized cities and several small cities. Considering the comparability between city sizes and the time constraints of the research, medium-sized cities and type I small cities were extracted from them. Then, we filtered out these cities along the Yangtze River, a total of eight, as the main initial targets for investigation. Their fall in the map shows that the eight cities are widely distributed from east to west along the Yangtze River, which helps us to get a comprehensive picture of the differences between the different cities.

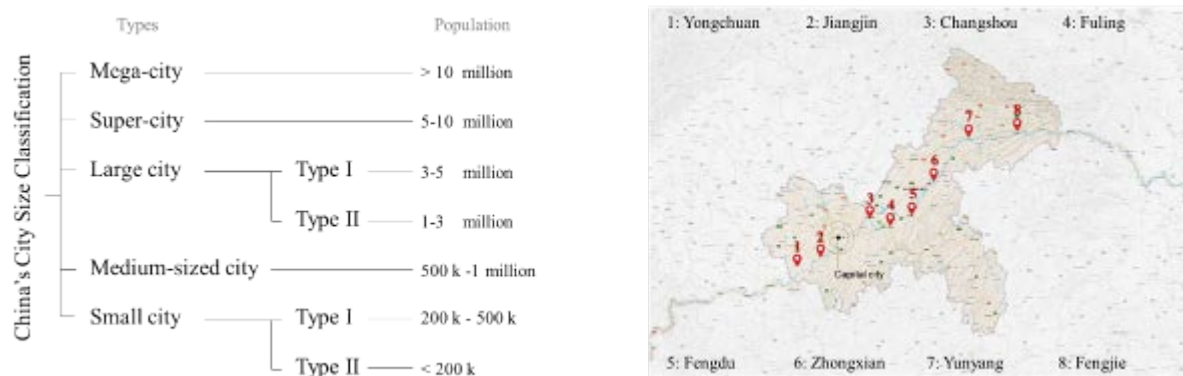


Figure 3: China's City Size Classification Standard and Eight City Cases in Chongqing

The population data and annual new completed floor space data were extracted for these eight cities from 2011 to 2020, and except for three medium-sized cities with a small increase, the population of the remaining five small cities is decreasing year by year. The new construction area completed in each city remains at a high value, with commercialized buildings accounting for about 50% of the total. Even in the medium-sized cities with population growth, the completed new floor space per capita is significantly higher than the previous floor space per capita. The population and construction data show a large contradiction, which is prominent in Changshou. While the population is declining by 20,000-30,000 per year, the new floor space completed keeps climbing, which is somewhat confirmed by our field research. As the photos show, there are many blocks in the new city area where construction is halted and a large number of new commercialized buildings are left unsold or unused.

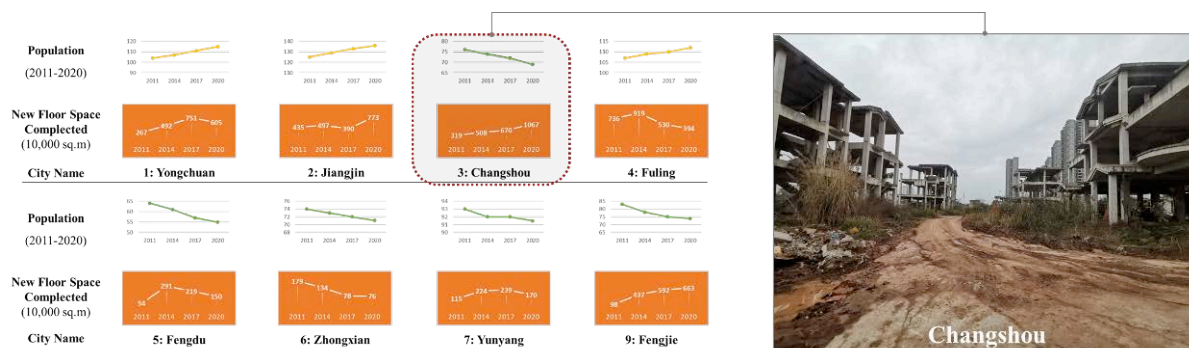


Figure 4: Contradiction between Population and Construction

A 10 km by 10 km satellite map was intercepted for each city. From the spatial layout, it is obvious that there are old and new city areas with distinct differences in street texture and scale in all eight cities, and then the distances were calculated between them. Using the center of old and new areas as endpoints, the traffic distances of the two connected main roads were calculated. As we can see, the distance values range from 3 to 10 km and can be divided into three classes: the first is about 3 km; the second is about 6 km; the third is more than 9 km. The different classes of distances between the old and new urban areas bring different levels of fragmentation in land use: the imbalance between occupational and residential, traffic congestion and aging population.

Fuling has developed a new city area 9.5km away. Although the two are connected by tunnels and expressways through the mountains and provide more employment, most residents still live mainly in the old city, which has lower prices, abundant commerce and

convenient facilities, and only travels to the new city for work during the day. The old city area, which is brightly lit at night, contrasts with the new city, which is vacant at night. With the distance narrowed to 5.5km, the old and new areas of Yongchuan get a better balance of development between them, achieving differentiated complementarity in terms of industry, housing prices and spatial experience, but with the frequent interaction between the two areas, traffic pressure has increased dramatically. Although new connecting roads are being added every year, the situation of traffic jams at important traffic nodes has not been significantly improved. The distance of 3.6km blurs the boundary between the old and new areas of Changshou, as its connection is very tight and smooth. A large number of people in the old city, especially young people, migrate to the new area. During the field visit, about 70% of the people in the civic square of the old city were over 60 years old, and different corners were occupied by various activities of old people. The extreme distribution of different age groups in the two areas is an aspect of spatial fragmentation that is difficult to reflect in the satellite map.

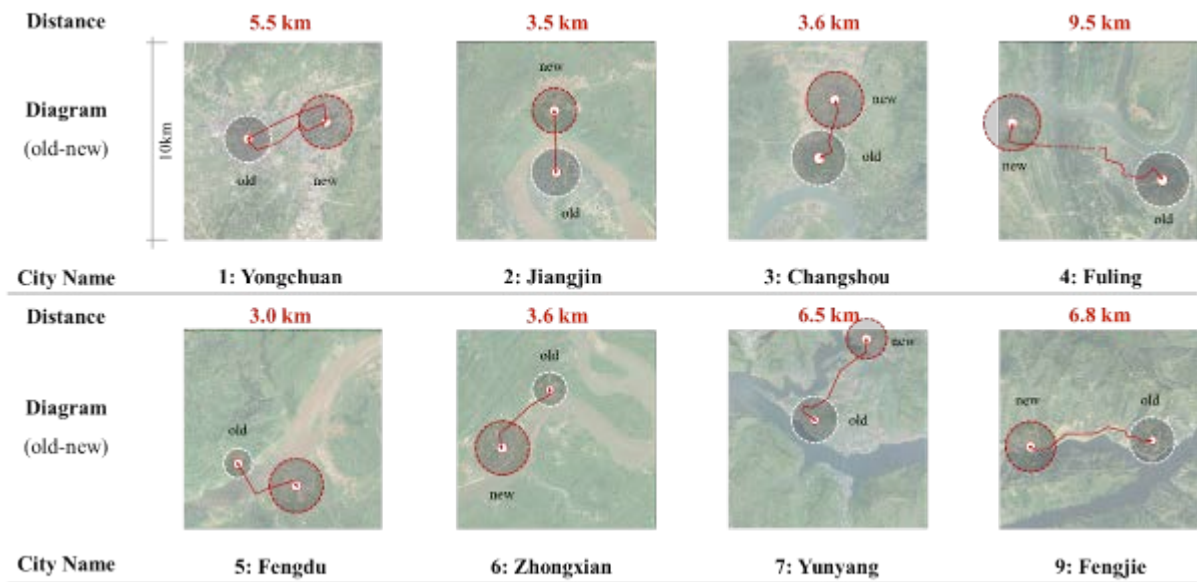


Figure 5: Distance Brings Fragmentation between New and Old Area

Such urban spatial fragmentation can be attributed mainly to the geographical conditions in which the cities are located. In order to discuss the urban spatial structure and land use more comprehensively, land use maps in urban planning and design since 2000 were collected from government departments of each city. It can be seen that the urban space is formed by the combination of multiple scattered clusters in a process of continuous growth.

Extracting four types of elements of each city: mountain, river, old and new city areas for abstract diagrams, it can be clearly seen that new construction lands cross mountains and rivers, finding relatively flat areas in steep slopes for the expansion of urban space, forming their own distinct structural characteristics.

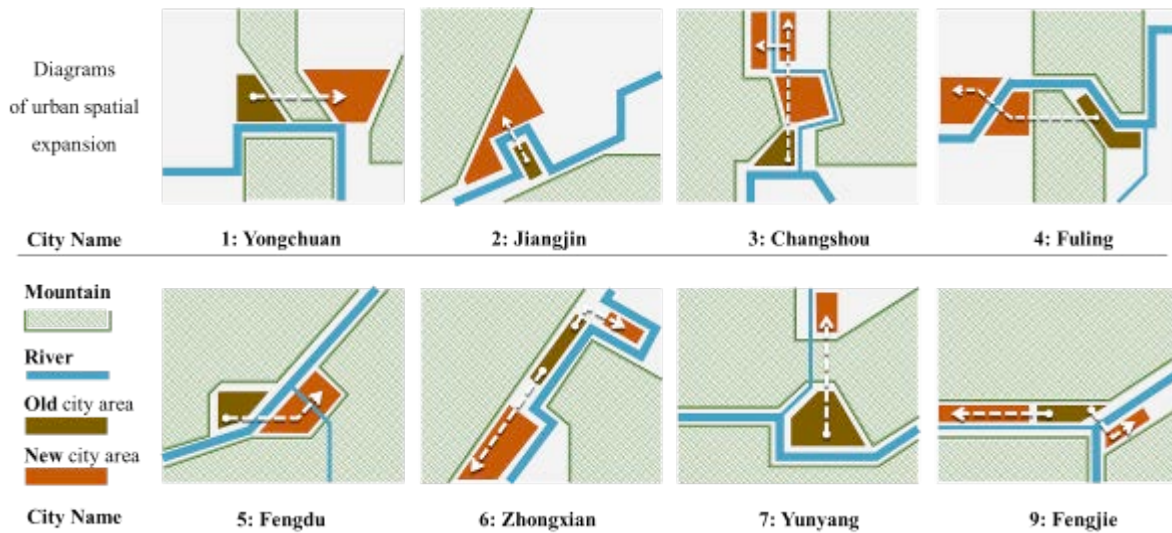


Figure 6: Distance Brings Fragmentation Between New and Old Area

The urban spatial structure of these cities can be summarized into four types. Type 1: Leapfrog development cross mountain. Land development area and resources are sufficient, but it is easy to cause tidal flow of people, and extensive land use management causes an imbalance between occupation and housing. Type 2: Coordinated development across the Yangtze River. It is helpful to the resource balance of different spatial clusters, but it strongly relies on bridge construction and has a long development cycle. Type 3: Longitudinal development along a tributary. The clusters are closely connected and communicate smoothly, but the population of old city areas is relatively aged, and the age structure of different clusters is easily imbalanced. Type 4: Linear development along the Yangtze River. Spatial development is limited by the land resources, but the efficiency of land use is relatively high, with high resilience and flexibility.



Figure 7: Distance Brings Fragmentation between New and Old Area

Historical Analysis: An Exemplary City

In addition to the important role played by geographical conditions, from a longer historical perspective of urban construction, the expansion of construction land and formation of spatial structure in eight cities are closely related to the history of changes in transportation modes. Before 1990, river transportation along the Yangtze River and its tributaries was the main transportation mode for transporting people, goods and commodities between these cities, and the areas around the river terminals became the earliest areas for urban construction. From 1990 to 2010, with the completion of the intercity highway network, land construction in the areas near the highway interchanges gradually accelerated. Urban space started to expand in this direction, and new areas continued to develop. After 2010, China entered the era of high-speed train, and railway stations led to the construction of a large amount of land around them, gradually becoming new population gathering centers, which have been developing until today.

The history of urban construction and land use in Changshou fully demonstrated this process and became an exemplary city selected in historical analysis. In the field investigation and visit, we took the relocation of a high school as a clue hoping to reveal the differences and common problems of land development and construction mechanisms in different historical periods.

During the river transport era, the urban space of Changshou could be divided into two clusters, the upper half and the lower half of the city. The lower half is the riverfront area at the estuary of the tributary into the Yangtze River. Major commercial and entertainment facilities and factories gathered here and developed a ribbon of residential areas. The upper half of the city is an inner terrace with an elevation of nearly 200 meters above the river surface, including cultural, educational, medical and sports land and corresponding residential areas. The two areas are distinctly different and interconnected in function. Important public services, including schools, are located at the junction of two areas and connected to each other by long, narrow stairways. People bought and sold goods on the road and shared facilities, making them the busiest commercial streets at that time. Nowadays, although the buildings have been vacated and people have left, these places have become important memories that linger in the local people.

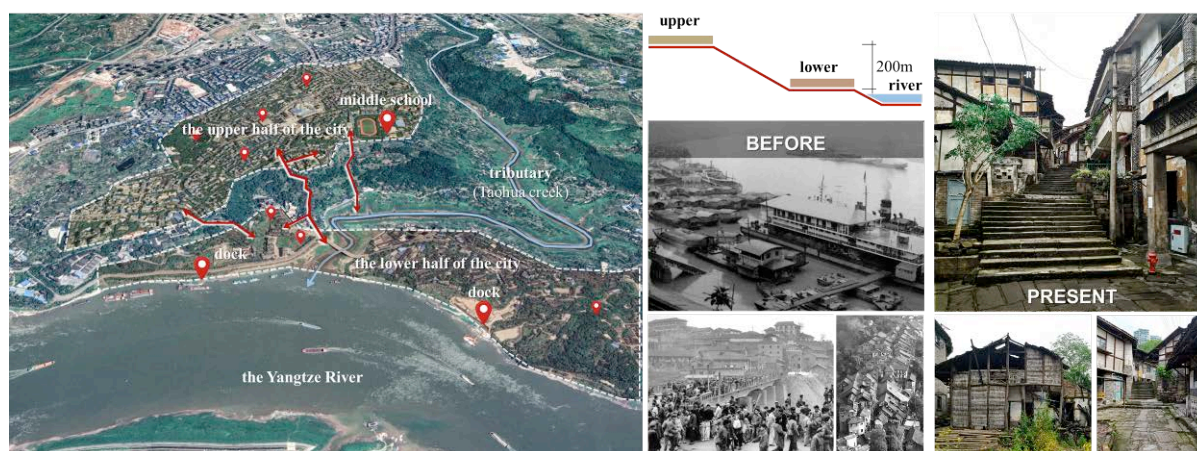


Figure 8: Land Construction During River Transport Era in Changshou (Before 1990)

Entering the highway era after 1990, the land construction in new city areas relied heavily on the development of commercial buildings. Some of the blocks near highway entrances and

exits were zoned for public services in the city planning maps and were first built in the new city around 2000. So a series of institutions, including middle and high schools, implemented a rapid relocation process. With the relocation of these institutions, the construction rate of surrounding land and housing prices were rapidly climbing. The new city areas are gradually entering a phase of rapid development and expansion relying on land and population dividends. Land auction prices and construction rates rose year by year during this period, but blind optimism about population and economic growth led to frequent incidents of long-term unused land and unfinished commercialized housings. On the one hand, it has caused great damage to the environment, and the water quality in downstream of the tributary has deteriorated to almost no flow. On the other hand, the development of the old city is completely ignored, and the urban spatial structure is seriously imbalanced.



Figure 9: Land Construction in Highway Era in Changshou (1990-2010)

After 2010, the problems of the previous phase of land development were taken into account. The planning map below shows that the previous rapid expansion by a single center had been transformed to the intensive development of multiple clusters, while schools were not relocated again, but placed in multiple smaller clusters in the form of branch campuses. Instead of focusing solely on economic development data and land development volumes, policies from the government encouraged different communities to plan flexible land use targets to create higher-quality urban spaces. At the same time, the water quality of the tributary and its surrounding ecosystem were strongly protected, transforming the abandoned riverside into an ecological city park and reintegrating it into a whole urban spatial structure.



Figure 10: Land Construction in High-Speed Railway Era in Changshou (2010-Present)

Conclusions

Based on the previous research and analysis, we summarize a five-part framework for intensive land use for architectural design. As shown in the Figureure, it consists of five parts: evaluation, accounting, grading, resilience, and collaboration. Specifically, we first study the site and its surrounding geographic, hydrological and climatic conditions and conduct an evaluation for ecological sensitivity. Based on this, the functional indicators given in the plan are accounted for and the construction capacity is readjusted. The construction plan is graded in terms of efficiency of use, which will be gradually realized in multiple stages to improve risk resistance. Establish a land information sharing platform before construction, so that neighboring blocks can be easily compared with each other and a multi-party cooperation mechanism can be formed.

Finally, this framework has tried to be used in practice for an architectural design project by us. We analyzed the geographical conditions of the site and the area where the new city is located, extracting information on daylight, rainfall, wind environment and topography to restore the real environment in different seasons. Using field visits with digital analysis, we assessed different ecological elements and determined the scope of construction. Based on this, we discussed with government departments about the modification of the previous plan to reduce the development capacity and increase the proportion of multi-functional space, forming a spatial structure based on respect for the ecosystem. For the different ecological and functional requirements in the whole site, a typology of multi-level spatial modules was sorted out and a multi-stage construction plan from 2025 to 2045 was set. Finally, the land construction plan and pipeline network information were summarized in a shared platform to facilitate overall regulation and control by the competent authorities.

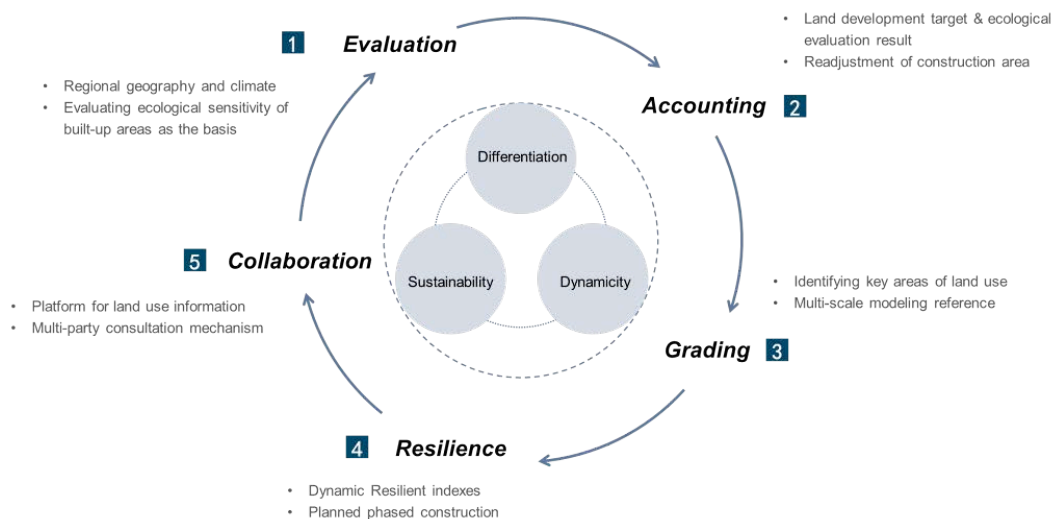


Figure 11: Intensive Development Framework for Architectural Design with Five Parts

Acknowledgements

This study would not have been possible without the valuable reference materials that I received from Tu Fuyi, Tang song and Zong Yuanyue, whose insightful statistical guidance and constant encouragement in the course of shaping my paper gain my deepest gratitude.

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Ecosystem Restoration as a Part of Energy & Environmental Life Cycle Contribution for Socio-Cultural Sustainability in Trubaindo Coal Mining, Indonesia

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The Asian Conference on Sustainability, Energy & the Environment 2021
Official Conference Proceedings

Abstract

This paper discusses the ecosystem restoration efforts conducted by TCM, one of the coal mines operating in West Kutai, East Borneo. The activities conducted by TCM starting from initiatives in managing good mining practices and are based on the principles of sustainable environmental management. Restoration efforts start with a simple step, namely, replanting the post-mining area by adding value to the socio-cultural-economic environment of the local community. This principle is used for various activities of TCM, ranging from Life Cycle Assessment, Energy Efficiency, Emission Reduction, B3 and Non-B3 Waste Management, Water Efficiency and Wastewater Load Reduction, to Biodiversity Protection which is all Community Empowerment based. Some of the programs presented in this paper include life cycle inventory efforts with a cradle-to-grave system for the coal extraction cycle to its use as fuel in metal smelting until it becomes ready products and its post-use. Then in mining activities, energy efficiency related to hauling distances, also associated with emission reductions. In addition, efforts to reduce B3 waste through recycling used oil waste amounting to 5 tons and reusing non-B3 waste type conveyor belts from mining activities as well. In water efficiency, runoff water also functions for watering the mine road by 1000 m³. It directly reduces the amount of water flow in the settling pond, reducing the processing load. Then efforts were made to plant local endemic tree species in the reclamation area and developed in cultural-based community empowerment activities at the Lou Bentian Lamin House, inaugurated at 1st Semester of 2021.

Keywords: Ecosystem Restoration, Good Mining Practices, Socio-Cultural-Economic, Life Cycle Inventory, and Community Empowerment

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Introduction

Management of the mining environment is closely related to the contribution to local social and cultural sustainability. From these activities, especially in developing countries, civilizations are formed, which together become a factor in changes in environmental quality. In line with the development of mining industrialization and population growth in the surrounding area, it is necessary to improve the environment's quality fundamentally. Trubaindo Coal Mining (TCM), a coal mining industry located in West Kutai (see Figure 1), East Kalimantan, a subsidiary of Indo Tambangraya Megah Tbk operating in Indonesia, is fully aware of this.



Figure 1: TCM Operational Area

Various TCM efforts in supporting ecosystem restoration in its concession regions, including community-based activities surrounding it as part of the good-mine closing efforts, are discussed in this paper. Implementing a program based on the life cycle of coal products to create the final post-manufacturing coal product is one of the initiatives. Then, in operational activities, energy-saving efforts are linked to indirectly reducing emissions. The main concern of operational activities is long mileage, requiring a proactive approach to fuel efficiency. TCM also makes an effort to conserve water by using rainfall to cleanse hauling roads, which results in a reduction in settling pond load in managing incoming runoff. Optimization is also taken in terms of waste management by utilizing operational waste, both B3 and Non-B3, to reduce waste generated. All of these initiatives are contributing aspects to long-term environmental management.

Green zones, woods, and regions that should be overgrown with plants are the main focus of the directly affected areas in the immediate context of ecosystem restoration. As a result, TCM has made efforts to manage post-mining sites by restoring vital plants, beginning with nursery activities in the Nursery area, as part of its active participation and implementation of good mining practice. Local workers were involved in plant management during these operations, and these activities were further developed during the construction of Lamin

House through cultural, socioeconomic, and environmental-based community empowerment programs. The Lamin House's sub-areas, which are based on the concept of ecologically friendly buildings, also reflect the representation of sustainable environmental management. The discussion below provides more information.

Overview of Life Cycle Assessment in TCM

A life cycle tracing of coal products from TCM's operating activities is one of the efforts to implement a sustainable environmental management program. The planned system boundary effort at this stage is Cradle to Grave, which covers coal mining and shipping activities as well as the production of fuel for metal processing activities. It is also a source of raw materials for electric motors, with this activity continuing until the product's estimated post-use cycle. However, in this paper, the system boundary is presented as Cradle to Gate as the following.

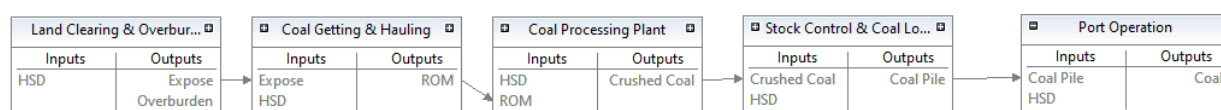


Figure 2: Scoping of the Cradle to Gate System in TCM

Primary data was collected from both TCM and contractors during the process, and it covered everything from fuel consumption to manufactured products, energy and mass balances, waste balances, and air emission cycles. The life cycle initiation approach in this study is mostly at the inventory data stage to identify hot spots, the impact of which would then be examined. At the very least, it is hoped that the inventory's hot spots are regions where improvements in energy management and its supporting environmental aspects have been implemented.

Furthermore, the presentation of superior programs based on environmental management and sustainable livelihoods is presented as follows.

Energy Efficiency: Using B30 for Vehicle Fuel Savings

TCM's operational activities significantly concern transportation distance from one location to another, which is quite challenging. For this reason, the focus on the management consumption of natural resources, such as fuel, is also carried out efficiently by modifying the transport distance. In addition, more environmentally friendly diesel fuel type B30 is set to replace all operational vehicles based on the laws and regulations. The activities of vehicles using B30 are shown in Figure 3.



Figure 3: Activities of Using B30 on Operational Vehicles

Through the initiative to use environmentally friendly fuels, energy efficiency increases 16.77 GJ throughout 2020. This program is part of a sustainable effort, which will continuously be developed in line with the development of environmentally-friendly fuel technology.

GHG Emissions and Conventional Reduction in Modification of Distance and Road Gradient during Hauling Activities

The most of GHG emissions are linked to energy efficiency activities in emission reduction initiatives. Meanwhile, conventional pollutants like SO_x, NO_x, particulates, and others are not typically linked to energy consumption. Since an increase in GHG emissions dispersed into the atmosphere is one of the global warming triggers, efforts to reduce emissions are an essential part of ecosystem restoration. As a result, modifications of distance and road grades in hauling operations are carried out in order to improve the performance of air quality control based on local concerns in TCM activities. Figure 4 shows an illustration of this program.



Figure 4: Modification of Distance and Road Gradient

This fuel use has proven to be very effective and can reduce GHG emissions by 82.56 tons of CO₂ and 101.49 tons of NO_x throughout 2020. This initiative includes activities based on LCA and continues to increase along with the development of mining activities.

Water Efficiency: Rejuvenation of Water Supply System Facilities in Non-Mining Activities

Regarding water efficiency, the main focus to support ecosystem restoration is preventing water leakage from the source. For this reason, in several locations, the clean water supply system facilities have been renovated, especially for non-mining activities. The activities include repairing water faucets to minimize leakage and replacing Galvanized pipes with HDPE to reduce the risk of corrosion. The documentation of the water supply system rejuvenation for supporting activities in TCM is shown in Figure 5.



Figure 5: Water Supply System Rejuvenation Activities

This activity is based on field conditions where potential leaks are often found. From this program, water usage is reduced up to 75 % compared to the previous year. This is probably due to the prevention of water leakage and the efficient use of water under the same operational and non-operational conditions. For this reason, starting in 2021, a pilot water audit will also be conducted, which focuses on inventorying the water supply system to be more efficient in minimizing potential leaks and optimizing the use of water resources.

Mining Wastewater Management: of Acid Mining Water Management Effectivity with Combination of Activated Lime and pH Adjuster based on Life Cycle Thinking

Acid mine drainage, which is normally managed using a sedimentation pond system known as a settling pond, is one of the necessary environmental aspects of coal mining activities. This pool uses gravity in a specific area to reduce levels of iron (Fe) and manganese (Mn), as well as physical water quality indicators like pH and total suspended solids (TSS). Figure 6 shows the documentation of TCM's settling pond management activities.



Figure 6: Settlement pond management activities

For settling pond management, besides managing acid mine drainage, there is also the management of rainwater or runoff that flows into channels around mining activities. For this reason, improvements are needed for the effectiveness and quality of water and wastewater management to reduce the potential load of wastewater to the environment, in this case, water bodies. Through this combination program of activated lime and pH adjuster, the principle of Life Cycle Thinking is used where the optimum combination will significantly support the efforts to improve environmental management sustainably. From the start, it is found that the effectiveness of reducing the wastewater load is possible to be increased with a target of reducing the pH adjuster by 50%.

3R of Hazardous Waste: Contaminated Water Management using Oil Trap with recycling system

There are routine vehicle checks and repairs in the housekeeping workshop area such as DT HD 785, LD Scania, Support Units for Fuel Trucks, Crane Trucks, and many other. One of the activities is also washing equipment that produces oil-contaminated water, which is included in B3, with the initial management of an oil trap separator unit. In this improvement, the effluent oil-contaminated water is recycled to replace surface water and water in the voids to wash light vehicles (LV). The description of vehicle washing activities using recycled water is shown in Figure 7.



Figure 7: Recycle Oil Trap for Washing Vehicles

This program has been implemented since 2017, with the results of reusing B3 waste of 4 tons per year. This activity also succeeded in supporting Life Cycle Thinking efforts by reducing water use in related operational activities.

Reduction of Solid Waste: Installation of a rubber conveyor to replace materials use

In the operational area, efforts have been made to reuse worn rubber conveyors to replace the use of materials in numerous places when processing non-B3 solid waste. As illustrated in Figure 8, one of them is in sports facilities.



Figure 8: The Utilization of Used Rubber Conveyors in Sports Facilities

It reduces the utilization of used rubber conveyors by 21.6 tons per year. This effort includes supporting Life Cycle Thinking which also supports Ecosystem Restoration by not adding new materials in the mining activity area.

Biodiversity: Conservation of local endemic plants of West Kutai and Local Fruit Plants

Biodiversity aspects have a critical role in sustainable environmental management, particularly post-mining activities, as the most significant contribution of ecosystem restoration efforts. As a result, conservation of native endemic plants in West Kutai, such as Jelutung, Duabanga, Meranti, Ulin, Kapur, and Kahoy, has been planted in the reclamation area as part of good mining practices. In addition, in West Kutai, there is a native Durian and Rambutan fruit plantation. Figure 9 shows the documentation of nursery activities at TCM.



Figure 9: Nursery activities for local endemic plants and local fruit trees in West Kutai

This program has succeeded in planting over 250,000.00 trees that grow and develop in the reclamation and revegetation areas. In this case, every tree plantation activity will contribute to ecosystem restoration in the future and reduce the potential for global warming. Every successful effort to rebuild this natural treasure requires consistent efforts and joint commitment in achieving sustainable development goals.

Community Development and Social Sustainability: Increasing Tourism through Lamin House Development

Most program contexts are only implemented on an internal scale of all the activities discussed in the previous section. Meanwhile, the Lamin House initiative in Dilang Puti – Bentian Besar, West Kutai, reflects environmental restoration efforts in the context of community empowerment. This program is part of a long-term plan to close the mine and replace it with a cultural and tourism system centered on community social welfare. The Lamin House is managed by the community, which is the main activity of the empowerment. It is a traditional house of West Kutai, and it functions as a tourism place to increase the rate of tourism, which is expected to be effective after the COVID-19 pandemic is appropriately resolved. The appearance of Lou Bentian's Lamin House is shown in Figure 10.



Figure 10: Lou Bentian's Lamin House Landscape

At the time of initiation, this program involved 500 communities and will continue to develop as local tourism conditions improve. As level-up participation in ecosystem restoration, Lamin House has a representation of environmental management aspects. The source of electricity for lighting and water pumps uses Solar Panels and uses rain-fed water primarily. There are also waste disposal facilities separated by type (B3 and Non-B3). In addition, the Lamin House, which is built from Kalimantan endemic wood, namely Bengkirai, Ulin, and Meranti Merah, is represented in the Lamin House garden by planting these wood trees. The integrated Lamin House program is based on the concept of Eco-Friendly Building, which is currently under review for the value of Social Return on Investment (SROI).

Conclusions & Recommendations

Of all the activities at TCM, the programs are based on direct or indirect ecosystem restoration efforts. We conclude that there are at least some benefits from the activities as follows.

- The use of B30 biodiesel fuel can increase energy efficiency by 16.77 GJ.
- Emission reduction resulting from modification of hauling distance and hauling road gradient is obtained by 82.56 tons of CO₂ and 101.49 tons of NO_x.
- Reduction of B3 waste from recycled oil-contaminated water by 4 tons.
- Reuse of rubber conveyor by 21.6 tons.
- Water conservation from the rejuvenation of water supply system facilities of 75%.
- The effectiveness of wastewater load from chemical optimization can save pH adjuster by up to 50%.
- The total numbers of local endemic plants planted in nursery activities are 100,000.00 trees, and local fruit trees are 150,000.00 trees.
- The total number of people who were empowered from the initiation of the Lamin Lou Bentian House program was 500 people involved and supported the activities.

There are many challenges and obstacles in conducting the programs and activities, notably during the COVID-19 pandemic, which is still happening today. Regardless of the challenges, it is hoped that the initiative will continue and help the community and

environment. Furthermore, all TCM entities, as well as public health concerns, are critical to the successful implementation of these ecosystem restoration operations.

Acknowledgment

We want to thank the management of Trubaindo Coal Mining, the management of ITMG Jakarta, and the entire TCM work team and stakeholders involved in each program. We realize that the biggest challenge of ecosystem restoration efforts is consistency in implementing the programs that continue to innovate and sustainable.

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Preliminary Life Cycle Assessment to Support Socio-Energy Innovation for Metal Processing Industry: An Approach from Pindad, Bandung – Indonesia

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The Asian Conference on Sustainability, Energy & the Environment 2021
Official Conference Proceedings

Abstract

In order to support and participate in the Sustainable Development Goals (SDGs) contribution, one of the instruments is the life cycle assessment as an approach to the study of clean production in the manufacturing industry. Pindad Bandung, which operates in West Java, Indonesia, is a metal processing manufacturing industry producing multiple Indonesian-made products. As innovation in supporting product quality and more benefits to the surrounding community, a preliminary LCA study was carried out starting from evaluating the energy balance and emissions in the production process. The resulting innovation supports financial savings and provides a competitive advantage in developing environmental-based community empowerment programs and core competencies of business processes. Several discussions are related to special programs in energy, environment, and community empowerment, each of which is related to the basic study of LCA. As for the LCA, the Gate to Gate system has a limitation with ton as the product unit. Meanwhile, in the energy and emission aspects, an electric motor program is internally manufactured to reduce the use of oil-fueled vehicles with an energy efficiency and reduce GHG emissions. In the 3R aspect of B3 Waste, there is a replacement program for coolant, which has a longer lifetime, while in Non-B3 Waste, 100% of the remaining raw materials are reproduced into multi-products. The water efficiency aspect focuses more on assessing water use and potential leakage, integrated with the water performance management roadmap. Meanwhile, in reducing the wastewater load, the unit is rejuvenated to optimize the wastewater treatment, reflected LCA valuation.

Keywords: Life Cycle Assessment, Innovation, Metal Processing Industry, Sustainable Development Goals (SDGs)

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Introduction

As commonly declared by various industrial sectors in almost all countries in the world, environmental management is an effort to manage the surrounding ecosystem, both with industrial activities and other domestic activities. To date, various sustainability-based environmental management efforts have been developed, particularly in manufacturing activities such as those carried out by Pindad Bandung. Located in Bandung, West Java, Indonesia, Pindad Bandung is a manufacturing industry that produces and processes multi-metal products.



Figure 1: Pindad Bandung Operational Area

Several integrated programs have been implemented in supporting economic, environmental, and social sustainability, as discussed in this paper. The instrument used to quantify environmental impacts in the next period is the Life Cycle Assessment, an indicator in the Sustainable Development Goals (SDGs). This paper also discusses the journey of Pindad Bandung in superior pioneering programs, increasing the capacity of work team personnel and improving towards continuous improvement over the last three years. The presentation will be further presented as follows.

Overview of Life Cycle Assessment in Pindad Bandung

Life Cycle Assessment (LCA) assesses the life cycle of products in a production process. The aim is to quantify the environmental impact generated per unit of product and identify improvement opportunities in improving resource efficiency. Previously in 2019, a basic LCA inventory was conducted on various products in each Pindad Bandung Production Division. As the continuation of the inventory, a temporary conclusion is obtained; it is decided to continue the preliminary assessment on the rail fastening component product with the limits of the Gate to Gate system, as shown in Figure 2.

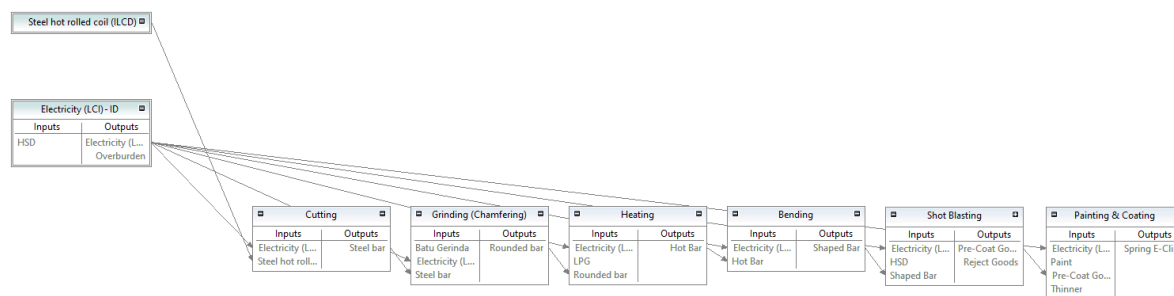


Figure 2: Limitation of Gate to Gate System for Rail Fastening Component Products

The product unit is per ton of metal processing products. The inventory is in more detail based on the production process and energy and emission balances. Later it is continued with the classification of impact categories and calculations. From this calculation, the value of the environmental impact contribution to the electric motor products includes hot spot areas that can be improved in terms of energy, emissions, and other aspects. The electric motor product also contributes to energy efficiency and emission reduction, as described in the section below.

Energy Use Efficiency: Electric Vehicle Innovation

The use of fossil fuels is one of the main issues in the unsustainability of natural resources and their balance on environmental quality. Two-wheeled and four-wheeled vehicles people use for daily activities also use non-renewable fuels, such as fossil fuels. The innovations in energy efficiency for products among the community, such as Electric Vehicles, really help improve energy efficiency by reducing conventional vehicles and switching to electric vehicles. The documentation is shown in Figure 3.



Figure 3: Electric Vehicle Innovation

This program is still in the production stage, and the research and development are still ongoing for more efficient innovations in the future. It has also been utilized for internal activities in the operational area and is calculated to increase energy efficiency by 0.87 GJ from reducing fuel oil[3]. If it is further applied to domestic activities in the community as consumers, the efficiency of using fossil fuels would be reduced gradually. Furthermore, the

supply of environmentally friendly electricity sources through renewable energy will also further improve energy efficiency in the context of LCA.

Lifecycle-Based GHG Emission Reduction in the form of Electric Vehicle Innovation

Emission reduction activities, especially those related to Greenhouse Gases, are generally directly associated with energy efficiency activities. One integrated form of innovation is the electric motor production program. The documentation of electric vehicle use in the operational area is shown in Figure 4.



Figure 4: Use of Electric Motors in Operational Area

In number, the electric motor program in operational areas can reduce GHG emissions by 85 ton CO₂ per year. For future improvement programs, it is hoped that the majority of operational vehicles are electric-based or environmentally friendly fuel-based. Many innovations have been made in other production activities in simplifying the production to reduce GHG emissions; some include conventional emissions.

Water Use Efficiency: Reducing Water Leakage by Replacing Pipe in Various Areas

Water efficiency activities are prepared based on the water supply system management plan for production activities and supporting facilities. Over time, it is found that there are several points of water leakage due to the rustic pipes. Leakage could contaminate the quality of the water, as well as causing ineffective water distribution in various areas. This paper discusses water efficiency efforts to reduce leakage in the supporting area, especially in canteen activities. Even during the COVID-19 Pandemic, operational activities in various production continue to operate. Supporting activities, such as canteens, continue to provide food for related employees. In this case, the water efficiency effort replaces Galvanized (iron-based) pipes with stainless steel pipes, as shown in Figure 5.

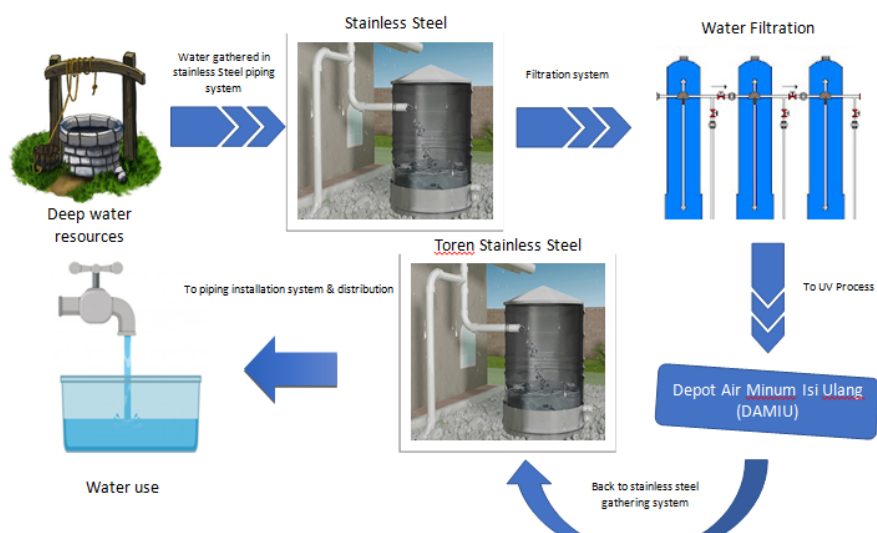


Figure 5: Replacement of Galvanized Pipe with Stainless Steel for Domestic Canteen Activities

This program can reduce the potential for leakage up to 23,556.00 m³ per year and eliminate corrosion potential due to pipe rusting. In addition, there are several other water efficiency innovations in the canteen activities, such as using water from artesian wells, which are directly processed using UV filters, etc. The future optimization is expected to use more efficient resources and also support the LCA-quantified SDGs.

Wastewater Management: Reverse Osmosis Unit Rejuvenation

At the wastewater treatment installation unit in one of the production divisions, efforts were made to rejuvenate the equipment to increase efficiency in reducing the load of wastewater to the environment. Furthermore, at the Surface Heat Treatment (SHT) facility, Reverse Osmosis conversion coating innovation was conducted, as shown in Figure 6.



Figure 6: Reverse Osmosis Conversion Coating Unit SHT

This program consists of several stages, starting from reconstructing the RO engine frame, continued with modifications and engine reinstallation. In calculation, this program can reduce the wastewater load by 1,200.00 tons with treatment unit effectiveness by 90%. This activity also competitively provides financial savings and supports LCA by optimizing activities from the company's scope.

3R of Hazardous Waste: Lifetime-based Coolant Replacement

Coolant or cooling agent is the chemicals used for the cooling process in production machines, often found in machining activities. Coolant has parameters that indicate whether or not it can continue to serve in the production system; commonly, it is shown in the service life, odor level, etc. The effort to reduce the Coolant type of liquid B3 waste by replacing it is shown in Figure 7.



Figure 7: The use of coolant in machining process

This program has been thoroughly implemented in the production division, especially in the special vehicle section, with a total B3 waste reduction of 33 tons per year. It strongly supports the LCA aspect where the reduction of B3 waste and the extension of service life is very integrated with reducing the environmental impact due to chemicals, in the category of LCA toxicity and global warming potential impacts.

Solid Waste Management: Utilization of Leftover Production Materials into Multi-Products

Metal processing manufacturing activities certainly manage various types of metal for production. In the process, various remaining materials with various shapes and sizes can be reproduced as other products. At least three production sectors manage Non-B3 solid waste into multi-products, including the utilization of scrap metal to be used as a railroad track, foundry waste into paving blocks and scrap metal to become counterweights. The documentation for the use of the remaining production materials is shown in Figure 8.



Figure 8: Reusing The Production Remaining Materials

Cumulatively, the remaining materials for metal-based production can be reprocessed into products of up to 1,000.00 tons per year. Each of these reused metal materials reduces the environmental impact due to exposure to scrap metal and provides a competitive advantage in derivative products with added values. More broadly, the program can provide economic benefits and production efficiency.

Biodiversity Conservation: Pigeon Breeding with Semi-Open System in Pindad Urban Forest

Although it might not be directly related to LCA efforts, Biodiversity also plays an essential role in environmental sustainability, especially for flora and fauna around the area. This paper discusses the semi-open system of Fantail Pigeons captivity, where the cage is designed to circulation area and makes it easier for species to breed in the City Forest Park area managed by Pindad Bandung. The documentation of conservation activities is shown in Figure 9.



Figure 9: Pigeon Conservation

This program has been effective since 2020 and has released 13 white dove species. This program also conserves the Fantaii Pigeon biodiversity up to 38 species. Meanwhile, this program is consistently implemented and monitored every six months periodically.

Community Development and Social Sustainability: Land Management of Former Integrated Landfill

As mandated by national regulations, Pindad Bandung also manages former landfills into an integrated facility based on urban farming and its development in social and environmental responsibility. The previous publications described the initial journey of the urban farming program and its benefits. This paper discusses the development and integration of the integrated environmental and energy management concept, shown in Figure 10.



Figure 10: Urban Farming Area Management Activities

The development of urban farming includes the provision of rain-fed water to replace the well water. In addition, alternative energy is developed to replace or substitute the use of

conventional electricity. At this stage, the feasibility and potential of using alternative energy from solar and wind power are under research, which is expected to provide long-term benefits for community empowerment. The basic SROI value calculated for the extended program which is 3.87 and economically, it can increase people's income in the era of social restrictions by 90% of the planned target. Social mapping and stakeholder involvement are also part of the activity; the monitoring and evaluation are conducted every six months.

Conclusions & Recommendations

Based on the activities and initiatives by Pindad Bandung in the initial LCA study, it was obtained that the activities mutually support efforts to reduce resources and reuse waste. From the explanation above, we conclude that there are at least some measurable benefits from the activities.

- The electric motor innovation can reduce the use of fossil fuels with an energy efficiency of 0.87 GJ and a reduction in GHG emissions of 85 tons of CO₂-eq.
- Reducing B3 waste from the use of Coolant type with a longer service life of 33 tons
- Utilizing waste metal materials into multi-products of 1,000.00 tons
- Water use efficiency by replacing the Galvanized pipe with Stainless Steel by 23,556.00 m³
- Reducing wastewater load from the rejuvenation of the Reverse Osmosis unit by 1,200.00 tons.
- A total of 13 fan pigeons were released.
- The benefits of the extended program of urban farming development program with an initial SROI value of 3.87.

Acknowledgment

We thank the management and work team of Pindad Bandung for their consistency in innovating and supporting the development of a sound governance system through capacity-building activities in 3 periods. We also thank all stakeholders involved in each program, directly or indirectly. We realize that with all the programs submitted, there are still many that require evaluation and improvement, which the main goal is to realize LCA that can quantify environmental impacts on the production process under research.

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Socio-environmental Life Cycle & Its Relevance to Long-term Sustainability: A Key Success of Jorong Barutama Greston Coal-mine Closure, South Borneo – Indonesia

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The Asian Conference on Sustainability, Energy & the Environment 2021
Official Conference Proceedings

Abstract

Environmental management is currently a priority in various industrial activities, ranging from upstream activities such as mining and energy related to the manufacturing sector to various consumer products for daily activities to represent downstream activities. This paper discusses the closure of the mine managed by Jorong Barutama Greston (JBG) about a long-term social environment initiated with the principle of Life Cycle Thinking. It includes several essential activities in energy management aspects, such as the utilization of acid mine drainage as a source of electricity 3.57 GJ, which is associated with reducing CO₂ emissions of 1.65 tons per year. In solid waste management, B3 waste is mostly reduced 0.7 tons from the source, non-B3 waste is mostly reused 1.66 tons. As for water management, water use efficiency effort is conducted by recycling. The main focus in wastewater is reducing a load of wastewater through the use of organic matter. To ensure the successful integration of biological resource conservation with community empowerment, a plantation activity for 1,625 plants as raw materials for organic dyeing for Sasirangan fabric products is a Banjar cultural excellence product. At least two groups of craftsmen have been empowered, consisting 20 members and community income stability per minimum wage during the COVID-19 pandemic. In the bigger picture, JBG performs a thorough optimization of the natural resources utilization and renewable and alternative resources to maintain the wellness of the surrounding environment. It is also culture as part of preparations for the mine closure period. It is hoped is that social services for the surrounding community will continue and provide good environmental management practices for the surrounding assisted groups.

Keywords: Life Cycle Thinking, Mine Closure, Environmental Management, Community Empowerment, Jorong Barutama Greston

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Introduction

Priorities in the current era of industrialization focus not only on operational activities; the environmental balance and the surrounding social community also play an essential role. In upstream activities such as mining, especially coal mining, many mines have entered the mine closure period and diversified their core business to be more environmentally friendly. Environmental friendly activities and lower emissions resources optimization are also an integral part of life cycle thinking efforts in the operational journey of mining activities until the mine closes. Jorong Barutama Greston – JBG (see Figure 1), a subsidiary of Indo Tambangraya Megah Tbk, which operates in Tanah Laut Regency, South Kalimantan Province, is one of the coal mining industries that has prepared its reclamation and revegetation activities by managing energy resources and environment and its integration with community empowerment.



Figure 1: JBG Operational Area

This paper presents several programs about sustainability in environmentally sound activities that focus on social communities based on the life cycle principles of low emissions and waste reduction. The programs implemented are practical innovations based on the environmental management approach at JBG. It is competitively part of good mining practices and implements social-economic support and environmental sustainability in the Sustainable Development Goals (SDGs), where one of the tools is Life Cycle Thinking. For this reason, the low emission life cycle principle in coal product management will be presented. In addition, the integration between biodiversity protection and community empowerment also plays a vital role in the success of economic and environmental sustainability for the surrounding community.

Overview of Life Cycle Thinking in JBG

JBG has conducted a basic Life Cycle Assessment (LCA) data inventory since 2019 with the Cradle to Gate system. The focus is on land clearing activities, coal extraction activities,

transportation, product processing, and coal products shipping. The shipping process is intended for the coal-fueled mid-steam industry; it is the electricity generator in Java. The unit of product produced is per ton of coal, with a category focus on the impact of energy use and emissions. The picture of the LCA process that has been inventoried by JBG is shown in Figure 2.

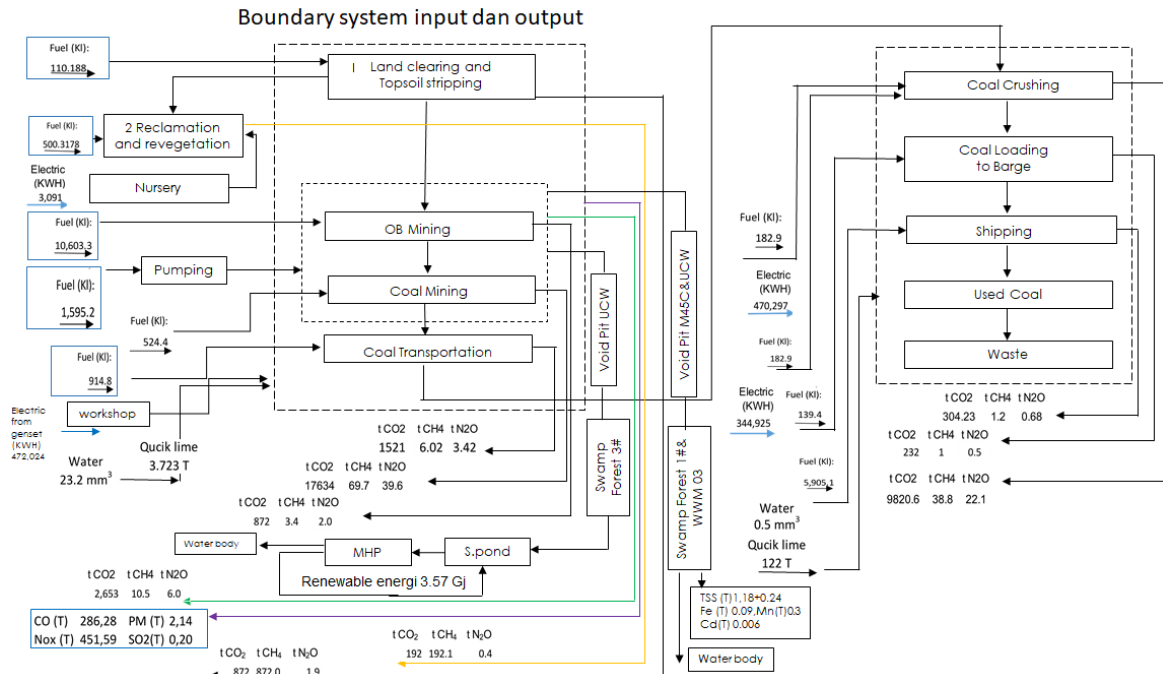


Figure 2: Limitations of the Cradle to Gate System at JBG

In 2021, a more detailed inventory will be carried out using the Cradle to Grave scheme, and it is planned to be published after calculating the resulting impact. Furthermore, the presentation of superior programs based on environmental management and sustainable livelihoods is presented as follows.

Energy Use Efficiency: Acid Mine Drainage Utilization As a Power Source with Additional Voltage (Ph) for Corrosion Control and Efficiency

One of the main aspects of the life cycle inventory effort is energy use, especially in operational and supporting activities at JBG. The electricity source is from the State-Owned-Electricity Company (PLN) with coal as a fuel source and isolated connection system. For this reason, one energy conservation effort is by using acid mine drainage as a source of electricity by adding voltage for energy efficiency and controlling corrosion at the same time. This program is an innovation that undergoes a simple trial process at JBG. The activity scheme is shown in Figure 3.



Figure 3: The schema of Acid Mine Water Utilization with Voltage Addition

This program is estimated to utilize electrical energy from acid mine water of 3.57 GJ based on initial calculations. Previously, the water in the settling pond has been used for electricity in the Micro Hydro Power Plant (PLTMH) program and several other integrated energy efficiency activities and efforts in the JBG area. These activities as a whole are a process to improve energy efficiency in supporting more efficient environmental sustainability.

Reducing Life Cycle-Based GHG Emissions by Stabilizing PLTMH current by utilizing Acid Mining Water

Aside from the energy efficiency factor, LCA also focuses on emission impacts that have relatively high relevance to mining activities, especially coal. The emission reduction program is an innovation, namely the current stabilization by utilizing acid mine water in the Micro-Hydro Power Plant (PLTMH) scheme. This activity utilizes electrical energy from environmentally friendly sources, which can reduce greenhouse gas emissions by 1.65 ton per year. The documentation of the utilization activities is shown in Figure 4.

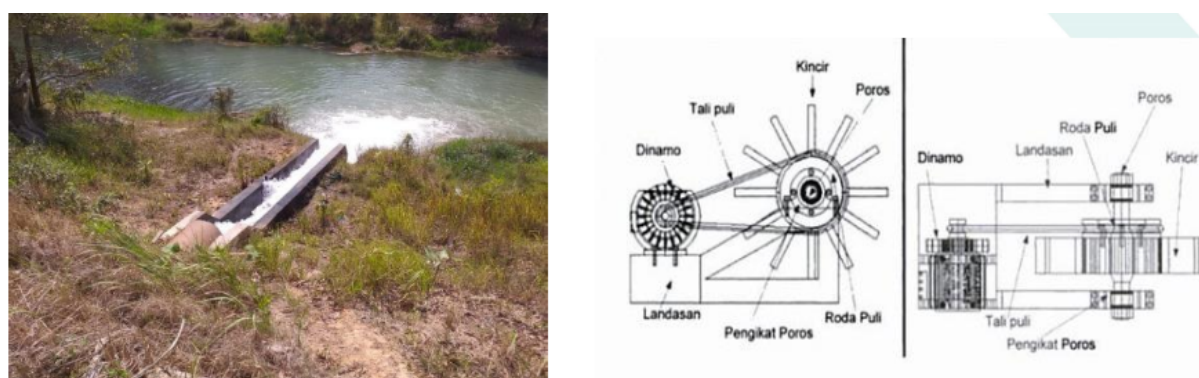


Figure 4: GHG Emission Reduction with PLTMH Optimization

Not only reduce emissions directly by reducing non-renewable electricity consumption, but this program also provides a competitive advantage for coal products produced by JBG. The coal fuel use of transport vehicles is among the lowest in mining activities because the

hauling road route at JBG is one of the closest. It means that overall, JBG's operational activities strongly support LCA efforts, as evidenced by the conserved energy usage optimization in the process.

Water Use Efficiency: Processed Water Utilization for Domestic Needs (bath and lavatory)

Still related to energy and emissions, the water efficiency activities in the MHP program are beneficial for reducing electricity consumption and optimizing water usage in the settling pond. The electricity generated from the MHP is used for lighting mining operations on the night shift. This activity is also integrated with Sparing Online, a continuous wastewater monitoring platform applied to coal mining activities. Previously, the power source was a battery; now, it has been substituted for micro-hydropower.

In water utilization, MHP can provide electricity supply to pump processed water by settling ponds; previously, it was discharged directly into water bodies. The water is used for domestic needs (bath and lavatory) in the WWM-16 area. The water utilization activities at MHP are shown in Figure 5.



Figure 5: Processed Water Utilization from MHP for Domestic Needs

This program can utilize water 18,000.00 m³, previously it was directly channeled into water bodies. This program also reduces a load of processed wastewater to the environment by reusing it. It means that these conservation efforts can integrate interrelated aspects in supporting the Sustainable Development Goals (SDGs).

Mining Wastewater Management: Reduction of Suspended Solids Load by Utilizing Grass as Organic Partition in Settling Pond Flows

As described in the water efficiency program, the processed wastewater is utilized for domestic activities in the mining area. It includes efforts to reduce a load of wastewater in water bodies around the mining areas. In addition, innovations were also made to manage

acid mine water by using grass as an organic partition in the settling pond flow. The documentation of the innovation scheme is shown in Figure 6.



Figure 6: Organic Partition in Settling Pond Flow

This program aims to reduce the suspended solids load in acid mine water. Based on the calculations, the program can reduce the TSS load by 300 tons per year by adding distributed grass resembling organic partition in the stabilization pond.

Domestic Waste Reduction: Utilization of Used Cooking Oil into Bar Soap

JBG is doing much innovation and developing solutions for practical problems in the field, one of them is domestic canteen activities where one of the wastes is the used cooking oil. In general, used cooking oil is a problem in all aspects of domestic activities, from local community activities to office canteen activities. For this reason, an innovation was made in recycling used cooking oil into bar soap within the scope of domestic use. The documentation is shown in Figure 7.



Figure 7: The Process of Making Used Cooking Oil Into Bar Soap

Based on the results of calculations and basic trials, this program will provide competitive benefits in utilizing non-B3 waste cooking oil of 0.25 tons per year. This initiative is still on a pilot scale in the scope of domestic canteen activities at JBG and is in further testing in 2021. In the future, it is hoped that product development integrated with community empowerment programs would also consider the administrative, technical, and institutional aspects.

3R of Hazardous Waste: Replacement of B3 Ink with Sasirangan Organic Dyes

In one of the community empowerment efforts during the COVID-19 pandemic, the Sasirangan handicraft products have been developed, one of which is a 3-layer cloth mask. In the process, the coloring of the sasirangan cloth uses synthetic ink, which contains Hazardous and Toxic Materials (B3). For this reason, an improvement program was carried out using replacing the coloring process using organic materials extracted from plants. The coloring activities of Sasirangan cloth are shown in Figure 8.



Figure 8: Sasirangan Coloring

This program is currently in the development stage and undergoes several trials for coloring techniques and organic materials. Based on calculations, this program can reduce the use of non-organic ink materials by 0.7 tons per year. This initiative is also integrated with aspects of liver protection and community empowerment, as discussed below.

Biodiversity: Eco-Printing Sasirangan with Mahogany Coloring Plants Produced by JBG

As previously explained, the integration of inter-sectoral programs is one of JBG's efforts to support good mining practices and sustainable environmental management. All of them are

based on life cycle thinking in energy management, the environment, and inter-aspect community empowerment. The main activities are reclamation and revegetation in protecting biodiversity, where seedlings occurred in particular nursery areas. In integrating biodiversity activities and community empowerment, the Mahogany tree nursery and conservation program can further extract to obtain organic dyes. These dyes are the essential ingredients and a mixture of eco-printing in making Sasirangan cloth. The Mahogany plant conservation activities are shown in Figure 9.



Figure 9: Mahogany Tree Conservation in JBG Nursery Area

JBG has been conserving Mahogany since 2021 with a total of 3,500 trees. Mahogany trees are included in the plantation with conservation status of **Vulnerable (VU)** and have been planted in several JBG reclamation areas as planned. Since this plant can provide natural coloring, it is further utilized in Sasirangan eco-printing products.

Community Development and Social Sustainability: Eco-Printing Sasirangan

As a form of environmental management programs and community empowerment integration, Eco-Printing Sasirangan is an innovation in developing product excellence. Moreover, in this innovation, natural organic coloring is made from self-cultivated plants for reclamation and revegetation activities at JBG. The environmental benefits are the reduction of synthetic dyes and the increase in Mahogany plants utilization which have been developed since the nursery phase. The documentation of the Sasirangan fabric coloring activity is shown in Figure 10.



Figure 10: Sasirangan Fabric Dyeing Process in Karang Rejo Village

The economic benefits of this program include savings in operational costs from purchasing synthetic dyes of up to 50 %, increasing the selling value as well as the income of community groups amidst the COVID-19 pandemic by 80% from the minimum wage of South Kalimantan. The social benefit is increasing knowledge about organic materials in developing the quality of Sasirangan fabric products. This program is expected to continue and develop further to the institutional stage. Also, the independent skill of the assisted communities is expected to provide a sustainable impact during the mine closure period.

Conclusions & Recommendations

The initiatives carried out by JBG specifically show integrated efforts to improve social, economic, and environmental sustainability through the Life Cycle Thinking approach since the operational period of mining activities. We conclude that there are at least some benefits from the activities as follows.

- The utilization of acid mine water as a power source by 3.57 GJ
- Emission reduction resulting from MHP by 1.65 ton CO₂-eq
- Reduction of B3 waste from the use of Sasirangan organic dye by 0.7 ton
- The amount of used cooking oil turned into bars of soap by 0.25 ton
- Water conservation by reusing processed water for domestics' purposes by 18,000.00 m³
- Reduced wastewater load from the use of organic bulkheads in acid mine water treatment units by 300 ton.
- The total number of mahogany trees planted in the nursery activity is 3,500.00 tree.

- The total community empowered from the development of the Sasirangan Eco-Printing program is 20 people with economic, environmental, and social benefits that support each other during the COVID-19 pandemic until 2021.

Acknowledgments

We thank the management and work team of Jorong Barutama Greston for their consistency and enthusiasm in innovating from time to time. We also thank the management of ITMG Jakarta and all stakeholders involved in each program implementation. We realize that of all the programs that have been delivered, it is not easy to prepare for mine closure based on good mining practices and their integration into sustainability in the post-mining economy, society, and environment, especially to the surrounding community.

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Life Cycle Thinking & Social Sustainability based on Capacity Building: An Insight from Indominco Mandiri, East Borneo – Indonesia

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The Asian Conference on Sustainability, Energy & the Environment 2021
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Abstract

The coal mining's environmental management issue has become a severe global concern. Various mining management activities in Indonesia are currently starting the mine closure phase and are concentrating on developing environmentally beneficial and low-emission products. Indominco Mandiri, a coal mining company in Bontang, East Kalimantan, has implemented a capacity-building program based on social and environmental sustainability and a life-cycle appraisal culture. IMM conducts various leading environmentally sustainable activities through this program, including The Establishment of a Solar-Farm in a mixture of non-renewable power plants into a single Micro Grid system for energy efficiency 7,200 GJ and emission CO₂-eq reduction of 2,000 tons each year. The reduction and usage of sources also conducted in the management of tons of B3 and Non-B3 waste to minimize the residue collected in the waste landfill. Concerning the aspect of community empowerment, IMM also focuses on the primary challenges related to the crisis of clean water with total water conservation calculated in m³, and product development from integrated plant cultivation and re-vegetation activities of Aren Genjah palm trees. In addition, IMM contributes to acid mine drainage control by reducing pollutant load. All of these activities contribute to the Sustainable Development Goals (SDGs) by ensuring economic, social, and environmental preservation in business activities and each stakeholder involved. There are numerous challenges in preparing for capacity building in all aspects, but this is considered a learning process with long-term advantages

Keywords: Environmental Program & Sustainable Activities, Indominco Mandiri, Capacity Building

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Introduction

Indominco Mandiri, known as IMM, is an Indonesian coal mining company located in Bontang City, East Kalimantan Province, under ITMG (see Figure 1). IMM handles coal mining and processes operations using the most acceptable mining operational principles and focuses on environmental sustainability. This is in line with what is mentioned in this paper, where IMM recognizes the need to strengthen the capability of employees in their area to implement an environment-based culture and sustainability in every line of the process to achieve environmental sustainability. This is also known as life cycle thinking initiatives, in which the operational principle ought to reduce waste and emissions.

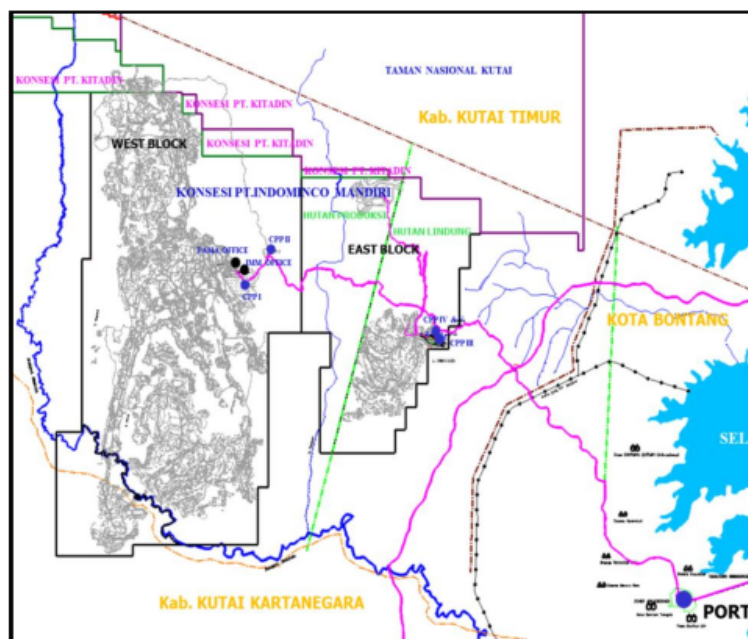


Figure 1: IMM Operational Area

Several programs generated and implemented by IMM are presented in this paper, including the operation of a 2 MW Indonesia's first solar farm which is integrated into the energy mix for power generation in an isolated Micro-Grid system. Regarding waste management, 3R approach is used to reduce waste discarded in the final shelter for B3 and non-B3 waste. Furthermore, acid mine waste management is conducted using effective techniques, and online monitoring is implemented to alleviate government movement across the country. Programs that promote community empowerment efforts in overcoming the issue of clean water crisis are carried out for water conservation and efficiency. Similarly, in the field of plant conservation and revegetation, seedling was conducted in the development of Aren Genjah plants to be cultivated by the community in order to produce products that support sustainable livelihoods.

Most of these activities are conducted in stages, with stakeholders involved, and are regularly monitored and assessed. This paper focuses on the program implementation process, which is centered on capacity building for the relevant team members. We hope that the SDGs' approach would be supported to balance the management of the new and renewable energy mix and operational activities that hold the future generations' welfare.

Overview of Life Cycle Thinking in Indominco

The Life Cycle Assessment (LCA) is the standard to measure the impact on the environment of specific operational activities, such as coal mining and its supporting utilities, in order to keep it in line with minimizing the resulting environmental impact. The programs described above are primarily implemented using the life cycle concept to produce a more environmentally sustainable cycle of activities. The operating system in Figure 2 represents the description of LCA on activities at IMM.

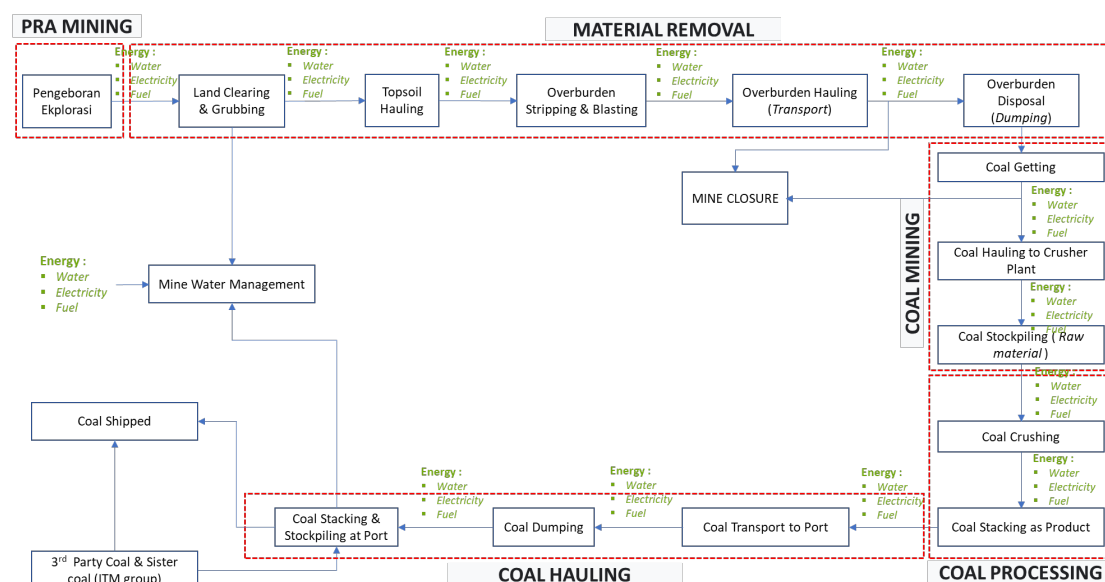


Figure 2: LCA-Based Activity Process Cycle at IMM

In contributing to the implementation of the life cycle assessment, IMM also conducts a basic inventory such as using raw materials to assess the impacts on the environment, such as emissions, wastewater, energy intensity, and so on. The system product from IMM's activities includes tons of coal, with Cradle to Grave as the initial step. The coal produced is then processed and used to generate power using a Micro-Grid system that utilizes solar and wind energy. The impact category is primarily concerned with emissions, eutrophication, and energy consumption, while the other categories will be adapted to the complexity of the monitoring activities. The goal is to identify hotspots with the most significant impacts on the environment. Thus, evaluations could be organized according to a priority scale for more effective and efficient managing resources, both in terms of industrial processes and environmental monitoring.

In addition, superior programs based on environmental management and sustainable livelihoods are explained below.

Energy Efficiency: Bontang Solar PV Hybrid Project

IMM has been running a 3 MW PV program with a 2 MW Battery Energy Storage and Micro Grid system since 2020. This program is a pioneer in Indonesia and Asia and is contributing to the use of more efficient and ecologically friendly energy. Figure 3 represents the appearance of the solar farm developed by IMM.



Figure 3: 3 MW Solar Farm IMM

Previously, IMM focused on electrical energy generated by its Steam Power Plant and Diesel Power Plant. The consumption of diesel and coal fuels can be reduced using this system which combines electrical energy sources with Solar Power Plant, with a total energy efficiency range up to 7,200 GJ per year.

GHG Emission Reduction from Renewable Energy Mix

As exposure to energy efficiency programs that are indirectly related to reducing greenhouse gas emissions. This reduction in GHG emissions is very significant because it is able to make 3 MW of electricity use from non-renewable fuels. In applying Life Cycle Thinking, this program has the potential to improve operational systems in all lines of coal mining activities that use a combination of solar and wind energy. Figure 4 represents the trajectory of reducing GHG emissions from the IMM Solar Farm mix.

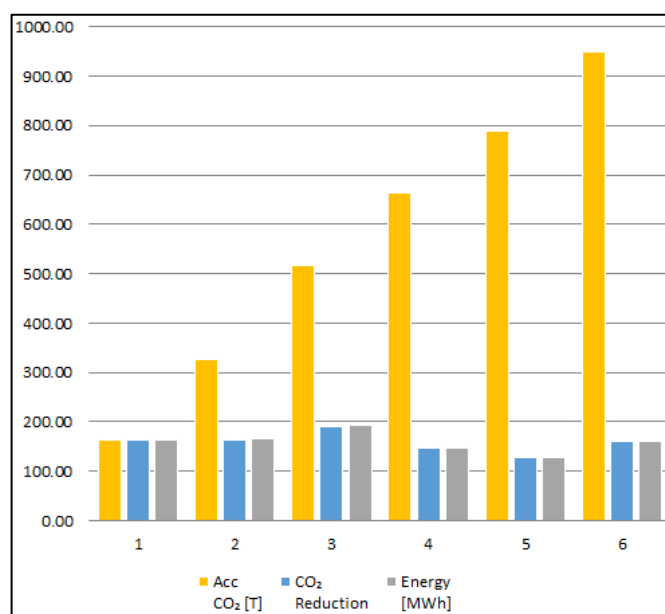


Figure 4: The trend of GHG Emission Reduction from Solar Farm Operation

According to this, the program can reduce emissions by an average of 2,000 tons of CO₂-eq each year. This means that the development of solar energy is a potential that provides a competitive advantage to the resulting product because it is based on the principle of sustainable energy conservation.

Water Efficiency: Provision of Clean Water and Community Sanitation

In terms of water conservation, there is an issue of the clean water crisis in the community, which is one aspect of promoting environmentally friendly, sustainable livelihoods and community welfare. This section explains the water efficiency program, which assists the community in acquiring clean water and substituting groundwater, which typically suffers from drought during the dry season. Figure 5 represents the process of providing clean water.



Figure 5: Water Treatment Plant Installation Activities

This program began in Santan Tengah Village in 2013 and has subsequently expanded to include numerous IMM-supported villages, including Santan Ulu Village, Santan Ilir Village,

and Kandolo Village. The total benefit of conserved water in this program is estimated to be 1,176.00 m³ per year. This program is in line with the activities conducted in the IMM area, where rainwater utilization is also carried out with a piped scheme. This will be explained further in the next publication.

Mining Wastewater Management: Making Trap Ponds for Road Watering

In terms of acid mine water management; the main focus is on reducing the load of wastewater which, after being treated and meeting the quality standards, will then flow into water bodies. In order to support the Life Cycle Thinking culture, efforts were made to minimize waste by utilizing rainwater and runoff that previously flowed into the pond sediment channel. This approach is conducted by making a trap pond in the reclamation area for watering hauling road. In principle, the runoff water does not come from mining activities; but if it has been channeled to the sediment pond, the same treatment must be conducted with other wastewater. The activity of watering plants in the reclamation area is shown in Figure 6.



Figure 6: Drainage system in IMM Mine Site

This program also reduces the load on the wastewater treatment unit by an average of 396,461.00 m³ per year. In addition, it can optimize plant conservation approaches as well as water use efficiency. All of these activities form an interconnected natural resource life cycle and can minimize environmental impacts.

3R of Hazardous Waste: Lubricating Oil Reduction through Lifetime Selection

In efforts to manage B3 waste, currently, the principle of applying 3R (Reduce, Reuse and Recycle) is being carried out by prioritizing the minimization of waste from the source. One of the efforts made in reducing the B3 waste is by selecting the type of lubrication oil material with a longer service life. The lubricating oil is used for equipment maintenance, especially in the area of coal processing and power plants. The activity of using oil as an equipment lubricant is shown in Figure 7.



Figure 7: Equipment with Oil Use in Operation

Even though it requires a higher cost, this activity can reduce the impact of lubricant waste, causing it to have the activity continued. This program has been running for 3 years and has succeeded in reducing the waste of used lubricants by an average of 13 tons per year.

Reduction of Solid Waste: Online Application System to Reduce Paper Usage

In terms of managing non-B3 solid waste in supporting activities at IMM, efforts were made to reduce paper usage massively by implementing an online application system in several lines of activity. At least until now, there are 4 types of online applications: for internal reporting, approval systems, Android-based for Yellow Cards, and requests for vehicle use. Some of the views of these applications are shown in Figure 8.



Figure 8: Online Application in One of Paper Reduction Program

From all these information system-based activities, the paper can be effectively reduced up to 1.25 tons of paper per year. In terms of life cycle thinking, this paper reduction contributes to reducing the potential for tree cutting as the main raw material for paper products. In addition, although the online system requires electricity, it uses a renewable energy mix as described in the energy efficiency section. This means that these are interrelated with each other and together can reduce the environmental impact of supporting activities.

Biodiversity Nursery and Conservation: Voluntary Seed Bank

In terms of the conservation of biological resources, IMM implements a program of collecting fruit seeds from employees and contractors to increase environmental awareness. It starts from small steps; the fruit seeds are to be planted in the reclamation area. The unity of this program is carried out by inviting employees to voluntarily keep the remaining fruit seeds and collect them in the nursery. This activity of voluntary fruit seeds collecting is shown in Figure 9.



Figure 9: Voluntary Fruit Seeds Activity for Nursery

The monitoring and recording of this program has been effective since 2019, and at least 500 kg fruit seeds have been collected. Furthermore, nursery and seeding activities become an inseparable part of reclamation and re-vegetation activities. This voluntary contribution is a manifestation of capacity building in terms of environmental awareness, not only for operational activities but also for employee daily activities.

Community Development and Social Sustainability: Product Development from Aren Genjah Palm Trees

In the aspect of community empowerment, the main focus of the program implemented is economic welfare and sustainable livelihoods. One of the programs that has been implemented for more than a decade is the Cultivation of Aren Genjah Palm Trees and its derivative products. Initiation activities have been conducted since 2006 with a focus on ‘one village, one product’ in Kandolo Village. From this program, derivative products from palm plants such as palm sugar, *pasak bumi* palm sugar, etc. are produced. After several years of consistency in program implementation, approaches were then taken to institutional, licensing, and group strengthening, which are still in progress today. The management activities of Genjah Palm are shown in Figure 10.



Figure 10: Aren Genjah Palm Cultivation along with the Community in Kandolo Village, one of IMM's program

This empowerment activity includes activities that are highly integrated from upstream to downstream of the program, starting from seeding and planting, processing sugar palm products to selling their products by community groups. To date, IMM has empowered 15 persons of group members with an average economic benefit of 50% higher comparing to local standard per year. The products produced have been marketed as many as variety of products.

Conclusions & Recommendations

From all the programs discussed above, the average program launched is based on mining activities and management of waste. At least there are several benefits in supporting social and environmental sustainability based on Life Cycle Thinking mentioned as follows.

- The use of Solar Farm is able to increase energy efficiency by 7,200 GJ
- Emission reduction from Solar Farm by 2,000 ton CO₂-eq
- Reduction of B3 lubricant waste by 13 tons
- Reducing paper usage by 1.25 tons
- Empowerment-based clean water conservation of 1,176.00 m³
- Decreased wastewater load from the use of runoff water by 396,461.00 m³
- The total fruit seeds collected from the Seed Bank program is able to produce 500 kg of seeds
- The total number of people empowered from Genjah Palm Cultivation is 15 people with economic benefits 50 % of the minimum wage.

The capacity building conducted for all layers of the IMM work team is still in the pilot stage and requires further monitoring and development in the future. In its implementation, each personnel need to adapt to many challenges and adjustments, and eventually will get better along with the intensive discussion and problem-solving process of the various programs.

Acknowledgment

We would like to thank the management of Indominco Mandiri, the management of ITMG Jakarta, as well as the entire work team and stakeholders involved in each program implementation. We realize that it is not easy to pioneer environmental culture efforts in supporting the sustainability of business processes without the cooperation and mutual support among teams in various areas. Hopefully, there will be better communication and integration of sustainability-based programs in the future.

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Pingtung County Recovered from Natural Disaster and Achieving the Goal of Providing Domestic Electricity 100% by Green Power

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The Asian Conference on Sustainability, Energy & the Environment 2021
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Abstract

After the completed “Aqua Solar Farm” project (installed capacity with 23.4 MW) due to typhoon Morakot in 2009, we are on the way to 100% green power for the need of domestic electricity in Pingtung. The first “Green Energy Promotion Office” was established to promote green energy in 2016. After engaging in “100% Renewable Cities and Regional Network” organized by ICLEI, Pingtung aims to the goal of achieving domestic electricity 100% provided by green power through the strategies of “Severe Subsidence Area” (SSA) project and “Multi-function Land Use.” According to the GIS tool guide issued by the U.S. Department of Energy, we selected around 3,800 from 13,164 hectares in SSA where are non-arable for installing photovoltaic (PV) power plants. Multi-function Land Use has been implemented without affecting the function of public facilities, including floating PV devices on a retention pond and ground-mounted PV panels on the dike, landfill, and court at school for green power. We provide a platform for stakeholders while adjusting regulation on the fee to attract PV investors for the SSA project could be a triple-win model for other cities to learn around the world. By the end of 2022, the installed capacity would be from 777 MW to 1 GW, satisfying the need for livelihood use powered by 100% green power.

Keywords: Non-Arable Farmland, Solar PV System, Green Power

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Introduction

Located at the southernmost tip of Taiwan, Pingtung County has a tropical monsoon climate. Spanning a total area of about 2,776 square kilometers it features a long and narrow terrain that is about 112 kilometers from south to north, with hillsides on the east and densely populated plains on the west. The main economic activities are the development of agriculture, animal husbandry and fisheries. Pingtung is struck by typhoons an average of 3–4 times a year. Among these, Typhoon Morakot brought more than 3,000 millimeters of rainfall within 72 hours in 2009, and the brunt was borne by the towns and villages of the coastal strata subsidence area to the west. In the past, large-scale aquaculture activities were carried out in this area via the pumping of groundwater. Over the years, the continuous subsidence of the strata has been unable to eliminate standing water. During this typhoon, moreover, the backflow of tides and seawater has had a disastrous effect. Half a year after the storm, less than 30% of the area was available for restoration of aquaculture and fisheries, and nearly 400 hectares of orchards had sustained damage (Lin, 2017).

In order help restore the livelihoods of farmers and fishermen, the Pingtung County Government makes full use of natural sunlight resources. According to data query results of the Global Solar Atlas geographic information system established by the Energy Sector Management Assistance Program that is managed in turn by the World Bank, if solar modules are installed at an optimal angle in Pingtung, the global tilted irradiation at optimum angle can reach 1,736 kWh/m². The converted average equivalent sunshine hours can reach up to 4.7 hours/day, which is much higher than the global average annual sunshine amount of 1,209 kWh/m² (equivalent sunshine hours is about 3.3 hours/day) (Global Solar Atlas, 2021). At the same time, we have considered multiple policy links such as the reconstruction needs of the disaster area, the restoration of state-owned land (groundwater conservation), the establishment of a complete green energy industrial chain, energy transformation and combined land utilization, and so on to promote a “Aqua Solar Farm” project. This has seen the installation of about 25MW of solar photovoltaic (PV) capacity in conjunction with abandoned farmland or fish farms, transforming it into Taiwan’s first large-scale ground-based solar voltaic case (Chen, 2012). This plan lays the foundation for Pingtung’s promotion of green energy and is leading Taiwan on the path of energy transition.

Furthermore, we took the lead in joining the “100% Renewables – Cities & Regions Roadmap” project of ICLEI – Local Governments for Sustainability in 2016. We therefore intend to simultaneously and comprehensively inventory the development potential of renewable energy in various townships and actively plan to promote the development of renewable energy in large volumes and set the power demand for the county’s 286,000 households (approximately 1.56 billion kWh). Our current goal is to replace traditional power supply with green power produced by renewable energy facilities.

Methodology

Strategies of Achieving 100% Renewable Energy Use

Having the great potential of renewable energy, we also work on changing policies to fit the restrictions on land use, power grid infrastructure, and the electricity market to balance the green energy industry with traditional agriculture. In 2016, Taiwan's first "Renewable Energy Promotion Office" was established to effectively work the renewable energy projects and be the window for the comprehensive renewable energy business and consulting services. The

promotion of “Severe Subsidence Area” (SSA) project and "Multi-function Land Use" are prioritized, two main strategies are step by step and tend to complement each other, moving towards 100% renewable energy.

I. Planning of "SSA" Project

In order to effectively plan for Pingtung’s suitable promotion of PV facilities and its complete program, Taiwan’s first “renewable energy database” was established in 2018 through use of the geographic information system (GIS). In the first step, we undertook a three-dimensional spatial layout of points, lines, and polygon to obtain information on different land use category and power system feeders. Furthermore, we adopted a strategy of “following the lines to find the land” as we screened land for the sake of promoting of ground-based solar PV targets. By using factors such as land that was non-arable, avoiding ecologically sensitive locations, and the availability of land acquisition. Meanwhile, we concurrently checked the status of adjacent transmission lines and power substations, used the “circumferential analysis” function in the Geographic Information System (GIS) to overlay land and feeder information, and filtered out land within a distance of 1 kilometer from transmission lines. This ensured that future cases can be connected to the grid within a certain distance to reduce power conversion and return process losses. The structure of database construction is shown below in Figure 1. This method of selecting the potential locations of renewable energy development is in line with the four aspects of “resource feasibility,” “technical feasibility,” “economic feasibility,” and “market feasibility” that are considered by the evaluation system used in the Renewable Energy GIS Tool Guide – Informing Choice of Tools to Support Decisions, published by the National Renewable Energy Laboratory of the U.S. Department of Energy in 2019.

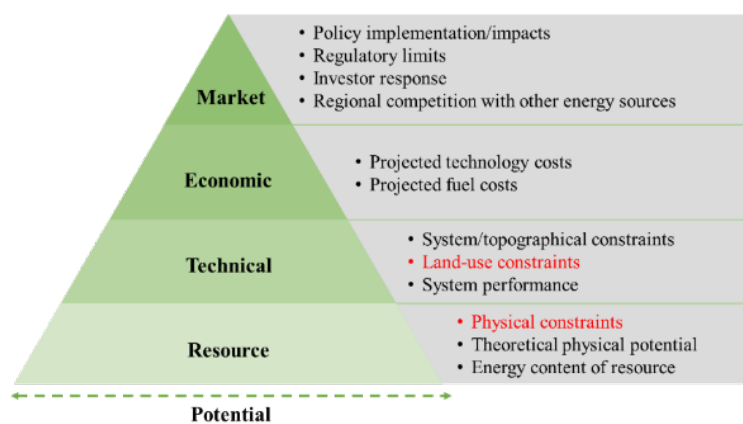


Figure 1. Geographic Information System tool guide for selecting potential locations of renewable energy development

(I) Non-Arable Land – Location Selection for Installing PV in SSA

The “Renewable Energy Database” overlaps the results of the 1996 survey of agricultural land productivity and importance by the Council of Agriculture of the Executive Yuan, and also overlaps the 2005 announcement of “SSA” by the Water Resources Agency (WRA) of the Ministry of Economic Affairs. The results show that 4 townships on the western side of Pingtung County, Donggang, Linbian, Jiadong, and Fangliao, are less suitable for agricultural operations in the coastal area (**Figure 2**), and 3/4 of the aforementioned areas are not suitable for agricultural development. Furthermore, all are encompassed by SSA.

We have divided them into the following 3 aspects for a total of 10 factors: (1) regulations and policies, such as the scope of policy plans, land use laws, and environmentally sensitive areas; (2) distribution of power equipment, such as the distribution of substations and power grids; (3) other social aspects, such as land ownership and property rights. We will exclude factors one after another in the subsequent site selection process (**Figure 3**) (Ou, 2019).

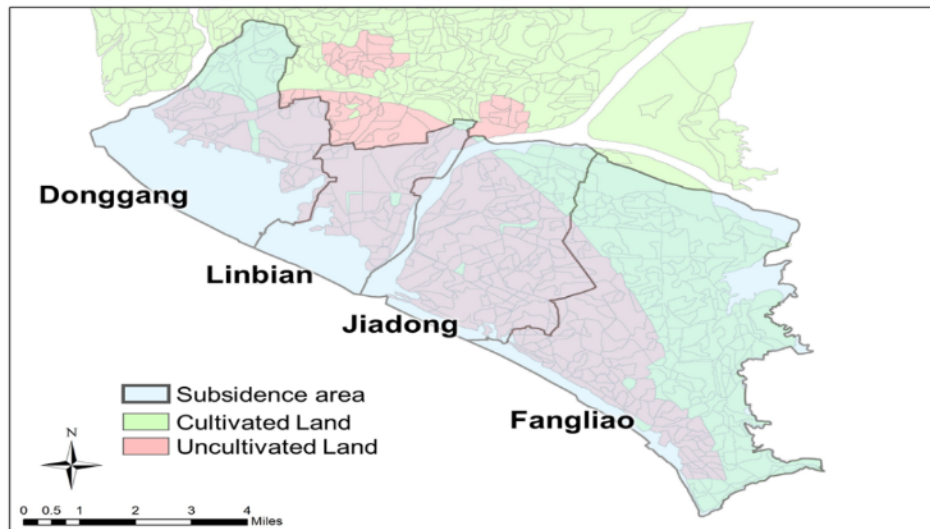


Figure 2. Map results for non-arable farmland

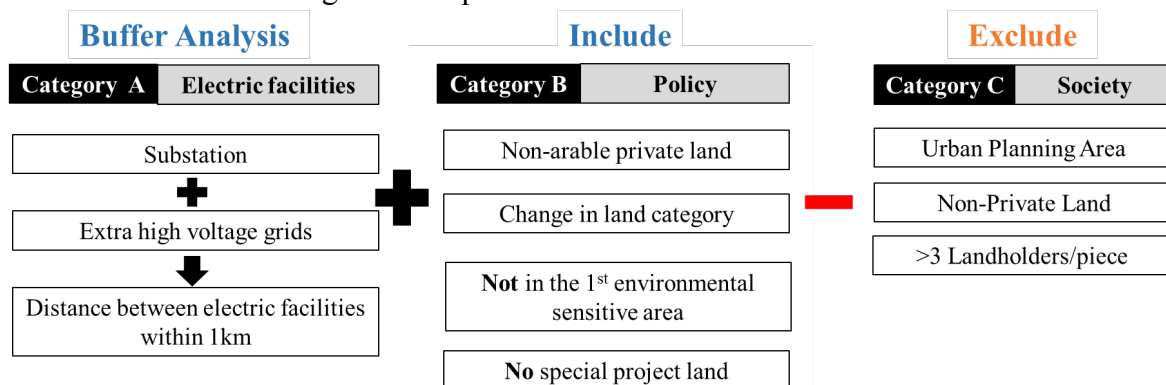


Figure 3. The criteria of selecting potential sites for GIS tool

II. Site Selection and Evaluation Method of Combined PV Facilities

Without changing the origin function of existing facilities, we consider how to develop various PV facilities within the concept of combined use of available space. First, we have prioritized the inventory of idle existing public facilities and space use functions. Through the integration of the public and private sectors, a demonstration case will be built for the emulation of other counties and cities in Taiwan for the sake of stimulating private participation. Through inter-office meetings, we have inventoried locations where PV capacity may be installed, such as detention ponds, dikes, landfills, and roofs of public buildings. In addition, the Green Energy Promotion Office shall further evaluate the feasibility, benefits and costs of the installation from the perspective of power equipment distribution, regulations and policies, and other social factors, while improving economic incentives and encouraging private industry to participate.

Result

I. Application of Pingtung Renewable Energy Database

We follow the subsidence area issued by WRA in 2005 including the four townships of Donggang, Linbian, Jiadong, and Fangliao in the western of Pingtung. We then further excluded conditions such as environmentally sensitive areas, special areas for cultivation and production, densely populated areas, and so on (**Figure 4**). From a total of 13,164 hectares of land, we thus determined a priority promotion range of about 3,800 hectares; and within 1 km from the grid, grid-connected ranges that are suitable for installation of booster stations (Figure 5).

After establishing the priority promotion range, we announced in 2018 the “Pingtung County Comprehensive Planning Review and Counseling Management Measures for the Solar PV Power Generation Industry in SSA” and officially launched the “SSA Project”. Furthermore, as of September 2021, all cases of field booster stations have been built within the recommended grid connection range, and the field of the solar PV case has been built outwards with the booster stations as the center.

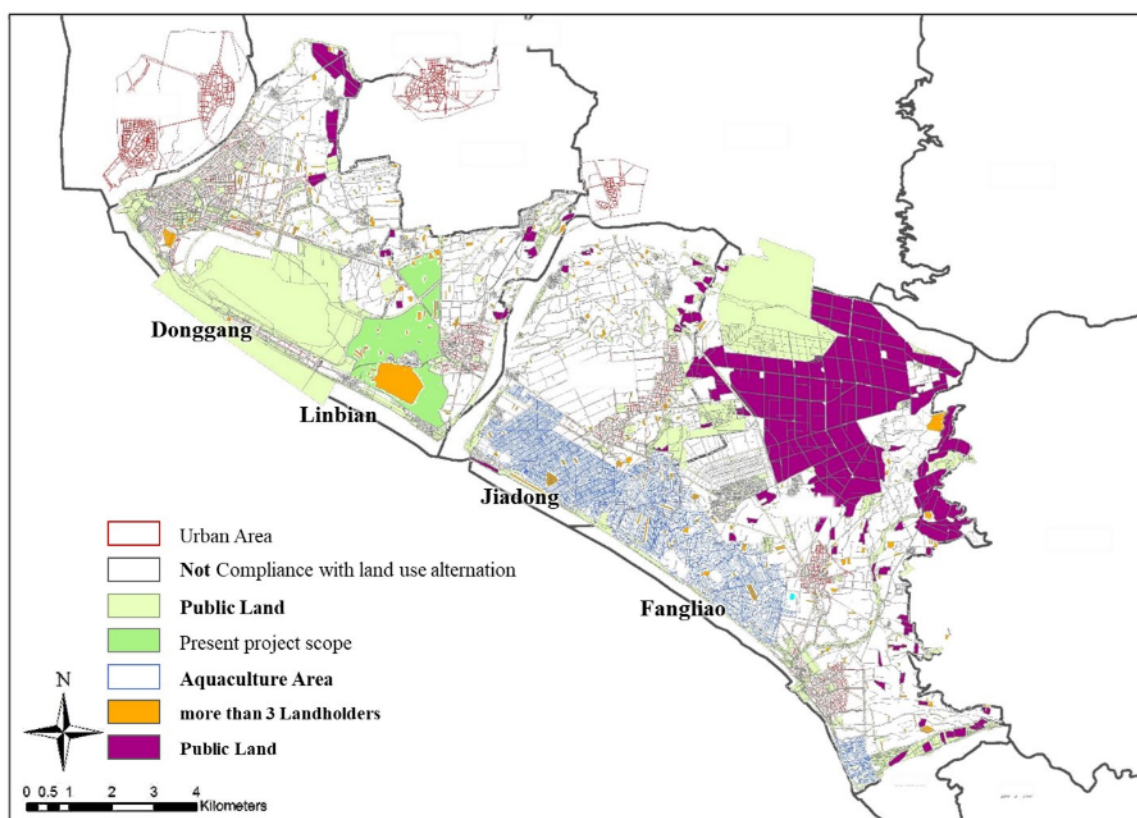


Figure 4. Pingtung County SSA project exclusion conditions

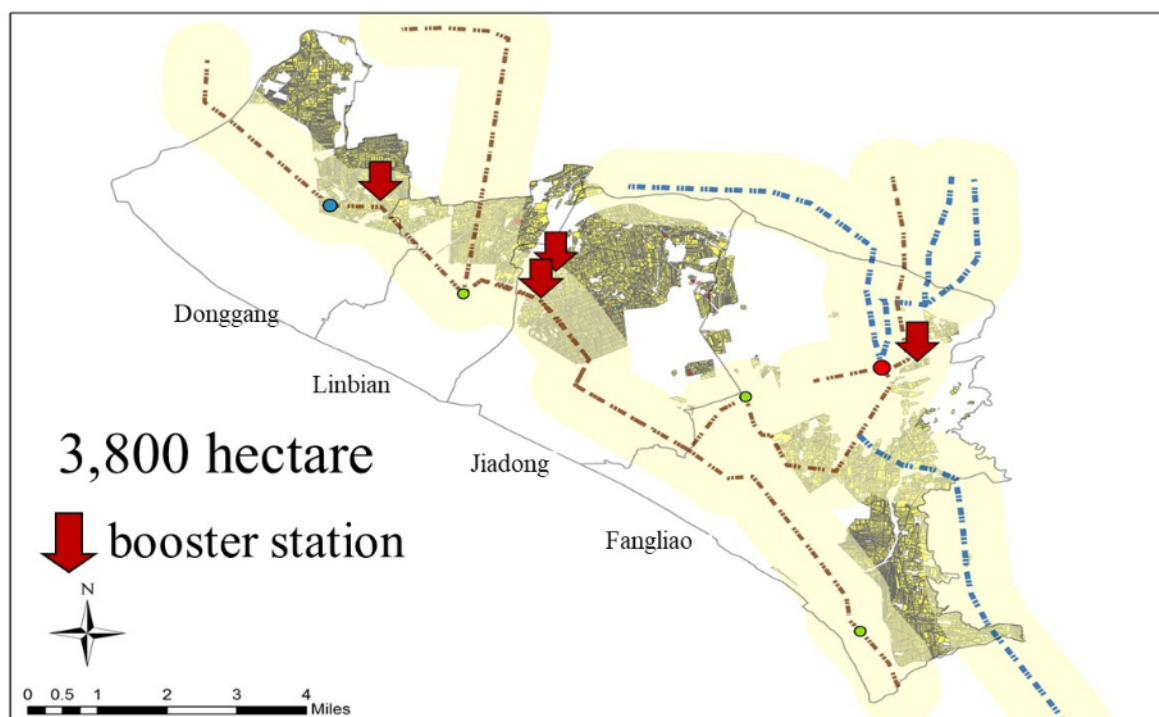


Figure 5. Solar PV project scope in SSA.

II. Implementation of the SSA Project

After the official launch of the SSA project, we also carefully executed overall planning in consideration of the fact that the plan is a project for collective private land development. This was in view of the past promotional experience of “Aqua Solar Farm” project to set up green energy on private lands, where a lack of relevant specification limits resulted in land and PV industry participants developing under a free market mechanism. This in turn led land development participants to collude with industry operators to falsely occupy feeder lines. All sorts of chaos occurred as participants did not install PV capacity yet were driving up the value of land and of feeders, or landholders would not obtain the protection of rights and obligations after leasing their properties. In order to effectively integrate and solve various problems, we officially implemented the SSA project in 2019 without preparing any budget. Through economic incentives, we selected qualified and competent investors to participate in this project, established a communication platform (Figure 6) between investors and landholders with administrative contracts to ensure the rights and obligations of both landholders and PV investors. This enabled landholders and PV investors to pursue private interests while also cooperating with the promotion of Pingtung’s green energy policy and pursuing comprehensive social interests.

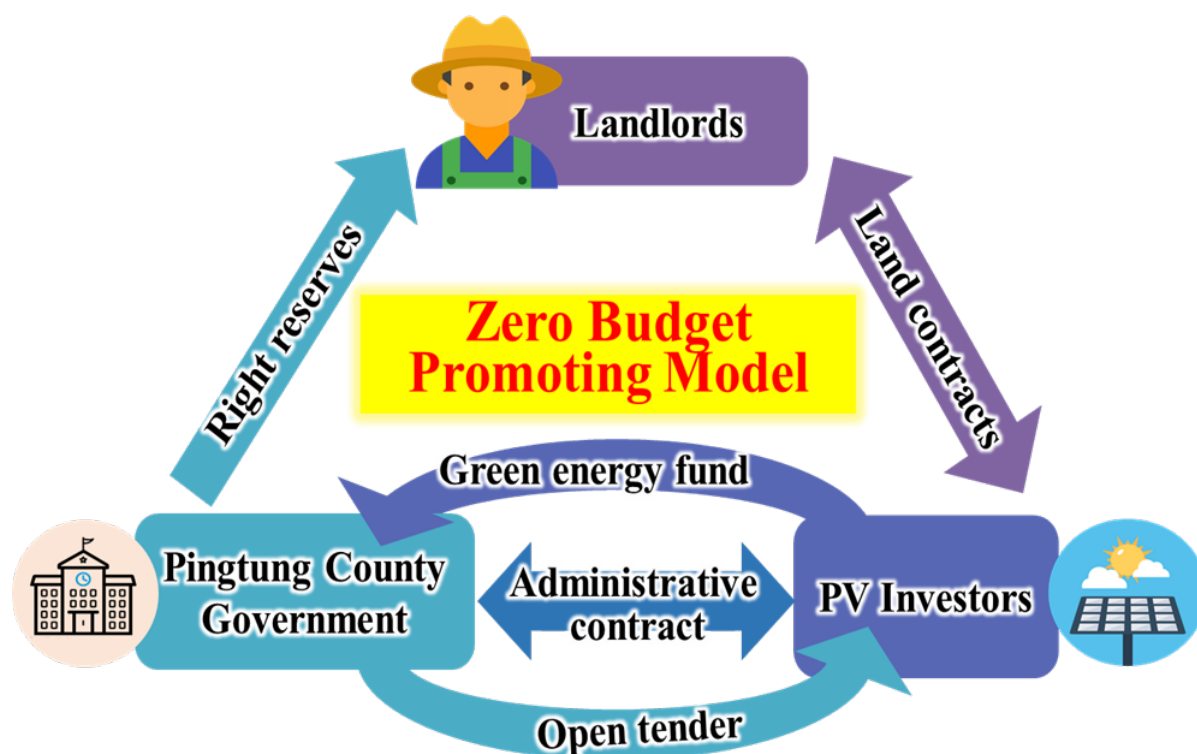


Figure 6. Zero budget promoting model in SSA project

(I) Regulating Investors to Fulfill Their Rights and Obligations

This plan adopts an open tendering procedure in order to strengthen the process and scale of solar PV capacity in SSA, and to prevent inferior investors from unscrupulously attempting to sign an administrative contract and seriously damaging the rights and interests of the landholders. The contract formulates autonomous rules: in regulating project counseling participants when changing category of land for setting up solar energy, although 50% of the current value of the land announcement fee is waived (rebate fee), it must be paid in installments to the green energy fund in accordance with the commitment to the administrative contract. With regard to the application procedures of investors, we will conduct simultaneous examinations in conjunction with relevant departments. The land category change process, which took more than 12 months in the past, has been shortened to less than half a year, and this has greatly reduced the time cost of investors' applications.

(II) Method of Protecting the Rights of Landowners

Private land shall be given priority for promotion in this SSA. Due to the large number of landowners in the SSA, they do not have a complete understanding of the background knowledge of PV installations on leased land and we have collected the relevant problems of PV installations on farmland in practice (including land category change procedures, taxation, agricultural insurance qualifications, and solar PV recycling). By building a digital platform, we have disclosed relevant information on the Internet. However, most local residents fall under the classification of digitally challenged senior citizens. Therefore, while in the early stages of plan implementation, we go to township offices to handle SSA project briefings with on-site explanations and answer to resolve public doubts. In addition, we also

use administrative contracts to require investors to set up special accounts for performance management trusts for landholders in order to protect their rights.

(III) Regulating Land Use Methods of Investors

Through the constraints of our “administrative contract,” the land leasing price can be maintained within a reasonable range. Moreover, before signing a land contract with the landholders, the investor must first explain to the landholders the method of land use, such as whether the land needs to be backfilled, and the source of the backfilled earth, so as to avoid illegal dumping and backfilling of the land without the government’s permit. After the investor’s acquisition of the land is completed, it can only be used to build PV facilities. In addition, after the 20-year feed-in tariff contract with Tai-power Company has expired, the landholder can also choose whether to continue to rent out the solar PV system according to the current setup or ask the investor to remove the solar PV facility and restore it to agricultural land.

I. Promotion of Benefits of SSA Project

(I) Centralized PV Facilities in SSA

Since our implementation of the “SSA Project” in 2019, 4 Ultra High Voltage (UHV) booster stations have been completed, with a total capacity of 140MW officially generating electricity. According to the current transmission line usage in this area, it is estimated that there will be a potential of 1GW that can be connected to the grid in the future. Taking “Operator A” in Jiadong Township with the greatest volume currently as an example: at present, 99MW has been connected to the grid for power generation, and it can be seen from the distribution block of the investor’s solar PV capacity (Figure 7) that the case is concentrated in the area within 3 kilometers from the booster station. Thus, through centralized development, land fragmentation can be effectively avoided in other townships in Pingtung County.

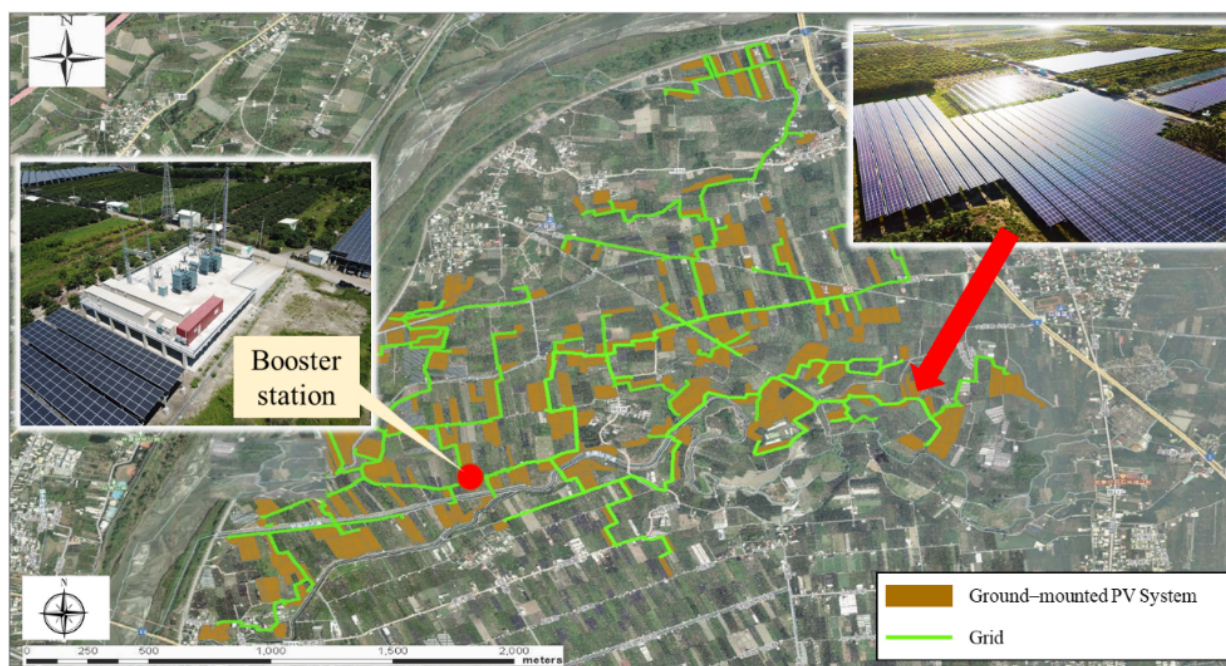


Figure 7. Schematic diagram of the distribution of land and grid-connected lines for the case of “Operator A” in Jiadong Township

(II) Extra Advantage for Environment from SSA Project

As of October 2021, about 140 hectares of non-arable farmlands or fish farms in SSA have been replaced to solar PV power plants. While expanding the green energy industry, we can also reduce the situation in which farmland and fish farms extract groundwater for cultivation or irrigation. Currently, the scope of the Multi-function Land Use project covers about 110 hectares of subsidence land with solar PV power plants. By letting the land lie fallow for 20 years and reducing the extraction of groundwater to irrigate crops, land subsidence can be slowed down. According to WRA (2021(a)), the conversion can reduce extraction by 2.97 million metric tons of groundwater annually. Similarly, in referring to the “Statistics on Aquaculture Area and Aquaculture Water Consumption” (WRA, 2021(b)), because there are also about 30 hectares of fish farms with PV, environmental benefits are seen as the conversion can reduce the extraction of 960,000 metric tons of groundwater for use as aquaculture fisheries every year. The calculation methods are as in Eq. (1) and Eq. (2).

$$\frac{\text{Water savings from installed solar power in irrigation area (10,000 metric tons/year)}}{\frac{\text{Total water consumption for irrigation (10,000 metric tons/year)}}{\text{Total irrigated area (hectares)}}} \times \text{Irrigated area replacement} = \quad (1)$$

$$\frac{\text{Water savings from installed solar power in breeding area (10,000 metric tons/year)}}{\frac{\text{Total water consumption for breeding (10,000 metric tons/year)}}{\text{Total breeding area (hectares)}}} \times \text{Breeding area replacement} = \quad (2)$$

(III) Adapting to Local Conditions and a Friendly Environment

Since the SSA has continuously sunk at the rate of 2 to 3cm every year, PV power plants are designed in a way that is adapted to local conditions and that is environmentally friendly (Figure 8), explained as follows:

1. From **Figure 8-A**. As this project adopts the principle of not changing the original topography to install solar equipment, therefore, for some subsidence areas that are prone to flooding, a design of elevated solar equipment is adopted. For example, see the highest booster station in the country (4 meters).
2. **Figure 8-B**. This area is still in a state of continuous subsidence. According to the National Cheng Kung University's Stratigraphic Subsidence Prevention and Control Information Network (Stratigraphic Subsidence Prevention and Control Information Network, 2021), the maximum subsidence rate in this area in 2020 was 3.3 cm per year. Therefore, in the design of PV equipment, the height and angle of the frame can be adjusted manually according to the subsidence of the ground.
3. **Figure 8-C**. We can cooperate with the data monitoring plan of subsidence areas of the Water Resources Agency of the Ministry of Economic Affairs, and regularly provide microclimate monitoring data within the scope of the case, such as the amount of subsidence and flooding depth of individual cases.
4. **Figure 8-D**. Considering the field of vision of local residents, this SSA is designed with a small inclination angle (7 degrees) to prevent glare and avoid affecting the safety of passers-by.

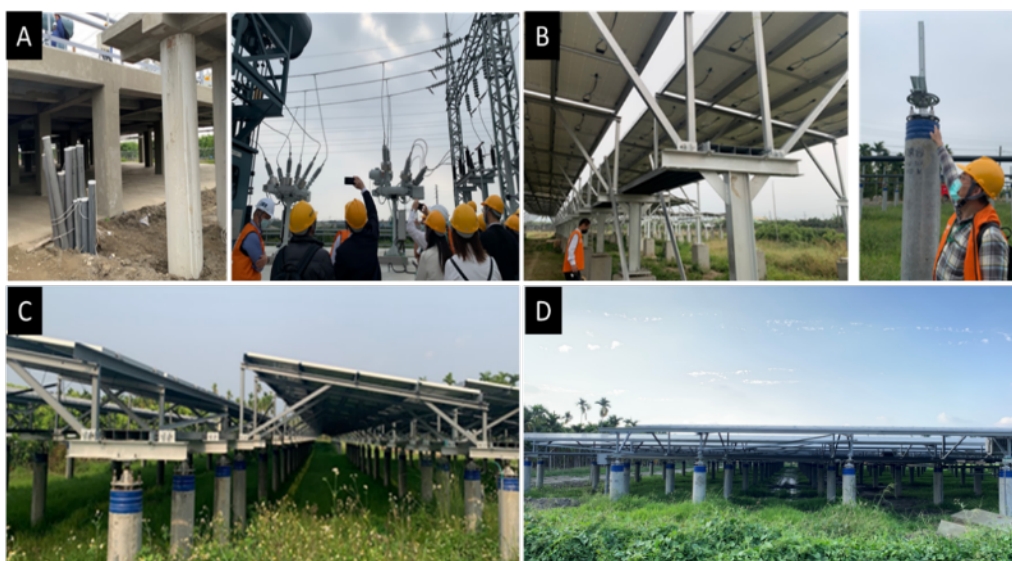


Figure 8. Explanation of design features aligning with local conditions for solar PV capacity in SSA

II. The Multi-Function Land Use Project

(I) Diversified Solar PV Facilities

The Multi-Function Land Use project is to utilize the available space of public facilities effectively (see Figure 9). This includes 9-A Floating PV on the detention pond, 9-B PV on the dike, 9-C PV on the landfill, and 9-D PV on covered court at schools. They all adopt the practice of installing renewable energy without affecting the functions of the original facilities. For example, the floating PV device on the retention pond, ground-mounted PV panels on the dike, landfill, and court at school. The first floating PV device with an installed capacity of 499 kW was built in Taiwan in 2016. Under the consideration of the Electricity

Act, if the installed capacity of the PV plant were over 500 kW, there would become a complicated application procedure. Therefore, the floating PV device installed with a capacity of 499 kW shows that this floating PV device is the first on-water PV device in Taiwan. The promotion of floating PV power plant also drives the local investor to invent floating devices spreading worldwide.

The other benefits of floating devices are that the system is eco-friendly with animals. Birds will build their nest under solar panels and lay eggs; baby birds co-exist with the device to become new biodiversity. PV panels could reduce water evaporation by 70%, and the water cools down the system making it around 10% more efficiently. After monitoring the water quality, the retention pond has no adverse effect.

(II) Setup of Biogas Power Generation on Livestock Farms

Pingtung has the largest number of pig farms in the country (approximately 1,500), and the number of pigs raised is 1.22 million, ranking second in Taiwan (Council of Agriculture of the Executive Yuan, 2021). The livestock industry is well developed and is an important source of supply for Taiwan's pork market. In the past, however, livestock raising bore a public perception that it discharges sewage and causes environmental pollution. We give active counseling to promote the recycling and reuse of livestock wastewater and cooperates with the installation of renewable energy such as solar PV capacity and biogas power generation. In this way, it can transform traditional livestock farms into clean, economically circular green energy livestock parks that effectively reduce the output of odor and that may also enjoy additional income from electricity sales. At present, 12 livestock farms in Pingtung County have installed biogas power generation with a capacity of about 1.5MW.

The installed capacity of renewable energy in Pingtung now is 777 MW. The annual green power generates 1.28 billion (kWh/year), sufficient for 235,000 households' use. Reviewing the past ten years, we successfully created several milestones in each year, especially in 2016. The first Green Energy Promotion office was established to provide green power for the need for domestic electricity. By having Green Energy Promotion Office be the sole window to facilitate the process of administration, till now, the installed capacity of 777 MW is seven times higher than its quantity in 2016 (Figure 10).



Figure 9. Methods of combined use of solar PV capacity for various types of land

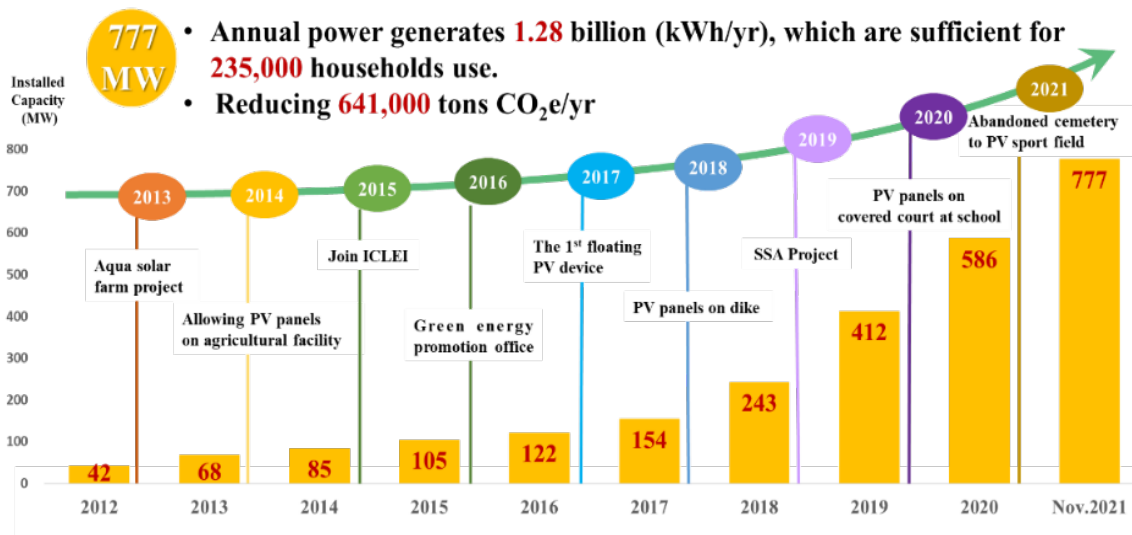


Figure 10. Installed Capacity of renewable energy in Pingtung

Conclusion

After taking the lead in considering various factors such as laws and regulations, land, and grid connection, we put forward effective methods to confirm locations for the effective development of renewable energy and adopted two strategies according to local conditions. Furthermore, we coordinated the overall planning of the grid distribution to promote the project plan, indicating the limitations of renewable energy promotion. As of the end of November 2021, the county’s overall grid-connected renewable energy installed capacity has reached 777MW, of which the SSA project has been connected to the grid with approximately 140MW. The combined PV facilities include public sector and private installations. We are continuing to move towards the goal of using 100% renewable energy for people’s livelihoods, to supplement the possible power supply gap after the decommissioning of Taiwan’s third nuclear power plant in the future.

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Electricity Savings and Carbon Mitigation Potential of a University Campus in Ho Chi Minh City, Vietnam

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The Asian Conference on Sustainability, Energy & the Environment 2021
Official Conference Proceedings

Abstract

This study estimates the electricity consumption and related carbon dioxide (CO₂) emissions for the buildings and facilities the main campus of the International University – Vietnam National University in Ho Chi Minh City, Vietnam. The AIM/Enduse model is used to calculate the CO₂ emissions in 2019 based on the recorded electricity consumption and project the electricity consumption as well as the CO₂ emissions for the two scenarios, namely 2030baseline and 2030mitigation, in 2030 based on the future strategic plan to evaluate the energy savings and CO₂ mitigation potential for the university. We found that space cooling accounts for 67.9% of total electricity use, followed by laboratory equipment with 19.1%, official equipment with 9.4%, lifting with 1.7%, lighting with 0.4% and remaining services with 1.4%. If electricity efficiency technologies are applied, especially in space cooling service, then the electricity consumption and CO₂ emissions in 2030 could be 13% less than baseline scenario. Consumer behavior, particularly students, is also important in increasing the potential of electricity savings for the university. These findings for A1-A2 buildings are necessary for IU-VNU in implementing energy savings and mitigation measures for the new building A3 to achieve sustainable investment and higher CO₂ mitigation potential.

Keywords: Electricity Consumption, Co2 Emissions, Aim/Enduse Model, Bottom-up Approach, International University - Vietnam National University

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Introduction

International University – Vietnam National University Ho Chi Minh City (IU-VNU¹), established in 2003, is the first public English-speaking university of Vietnam. The university has many twinning programs and exchange programs with other universities in United State (US), United Kingdom (UK), Europe (EU), Australia, Japan, etc. Therefore, it's important for IU-VNU to learn and apply the energy savings practices from these countries. In which, improve energy efficiency, investing in innovative energy production technologies, increase young student's energy and environmental awareness and reduce energy waste are considered as mitigation measures towards zero energy or even zero carbon communities by many university campuses all over the world.

At service-specific level, Stefano (2000) evaluated the potential for energy efficient lighting to save energy and reduce CO₂ emissions at Melbourne University, Australia; Abolarin et al. (2013) presented the energy efficiency improvement for lighting service at University of Lagos, Nigeria; and Gorgulu and Kocabey (2020) investigated the energy savings potential of lighting retrofit scenarios in outdoor lighting systems in Burdur Mehmet Akif Ersoy University, Turkey. Besides, Vásquez et al. (2015) conducted the evaluation of greenhouse gas (GHG) emissions and proposals for their reduction in travelling by different means of transport at Universidad de Talca, Chile. On the other hand, Park et al. (2016) proposed the optimal photovoltaic (PV) system implementation strategy to achieve the national CO₂ emissions reduction target in 2030 with a focus on educational facilities in South Korea. Moreover, Semprini et al. (2016) showed the importance of energy audit and management in heating system for University of Bologna, Italy; while Shea et al. (2019) provided the results of reducing air handling unit energy usage through controls-based energy efficiency measures for University of Dayton, US.

At whole-building level, Chung and Rhee (2014) analyzed the potential opportunities for energy conservation in existing buildings on university campus in South Korea based on field survey of energy consumption patterns; Emeakaroha et al. (2014) performed the role of a novel integrated system combining human psychology with technology feedbacks to assist real time energy conservation for University of Kent, UK. Moreover, Escobeto et al. (2014) estimated energy consumption and related GHG emissions for the buildings and facilities of the main university campus at the National Autonomous University of Mexico; Yeo et al. (2019) estimated the energy efficiency of educational buildings with the case study of buildings in City University of Hong Kong, China; while Liu and Ren (2020) conducted the research on the building energy efficiency design strategy of Chinese universities based on green performance analysis; Mohammadalizadehkorde and Weaver (2020) quantified potential savings from sustainable energy projects by an energy efficiency assessment for Texas State University, US. Besides, Olivieri et al. (2020) studied the potential of installing PV distributed generation towards an emission-free supply at Universidad Politécnica de Madrid, Spain. Moreover, Mytafides et al. (2017) discussed about the transformation of a university building into a zero energy building in Mediterranean climate under the context of EU energy efficiency initiatives. Kolokotsa et al. (2018) summarized the energy technologies and performance in different university campuses, with detail study for Technical University of Crete, Greece.

¹ International University – Vietnam National University Ho Chi Minh City

It's worth noticing that educational buildings have high potential in energy savings and GHG emissions reduction. Following these studies, this research aims to conduct a GHG inventory and projection for existing buildings (A1 and A2) in the main campus of IU-VNU. Different scenarios are developed with various assumptions on using conventional technology and applying advanced technology that are needed to comparison between the level of energy consumption and GHG emissions in base year 2019 as well as in target year 2030. These assumptions are not simply concerned with energy-efficient devices for less GHG emissions, but also include selection of economic efficient technologies to ensure a profitable operation for the university.

Overview of Energy Consumption in IU-VNU

Ho Chi Minh City (HCMC²) has a tropical weather with the warmest months are April-May and the coldest months are December-January. Figure 1 shows the monthly average temperature measured at Tan Son Hoa station in HCMC for the past fifteen years (the thermometer is located at two meters above the ground), in which the average temperature varies typically between minimum 25.9 degrees Celsius in January and maximum 31.3 degrees Celsius in May. In the base year 2019, (red line-with-markers in Figure 1), the temperature increased to be hotter than previous years in most of the months. The record shows that the weather in HCMC is getting hotter, that might lead to the increasing demand in electricity for cooling service.

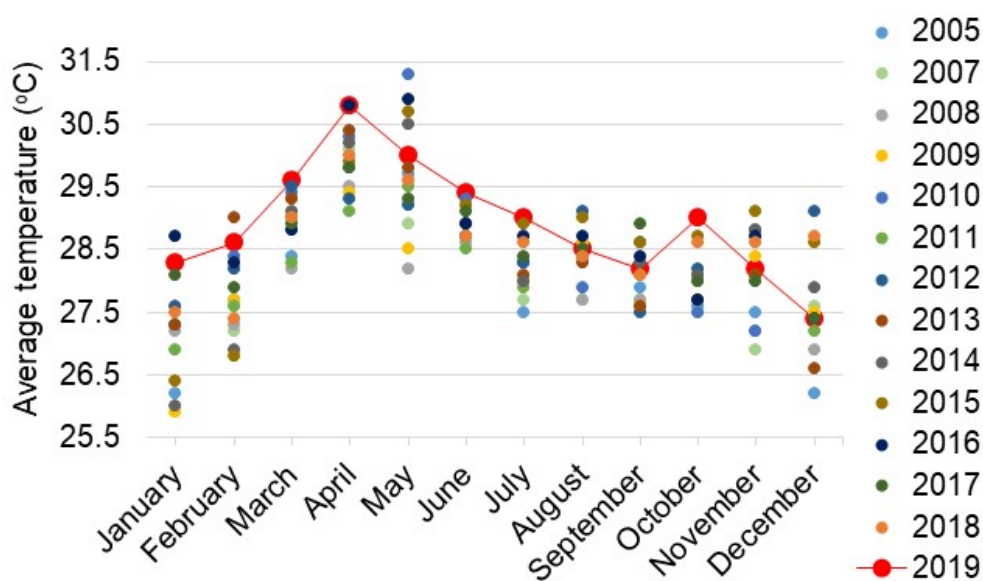


Figure 1. Monthly Average Temperature over 15 Years in Ho Chi Minh City, Vietnam

IU-VNU is paying energy bills for activities in buildings and facilities as well as transporting faculties and staffs by shuttle buses, in which more than 80% of energy bills is for electricity. Figure 2 shows the record of total electricity consumption in IU-VNU in five-year period (2016-2020) based on electricity bills. There is an increasing trend in electricity consumption with 1.9% - 6.2% increasing rate annually; from 2.23 GW in 2016 to 2.28 GW in 2017, 2.42 GW in 2018 and 2.52 GW in 2019. However, in 2020 when Covid-19 pandemic happened, the university had to switch to online study for several months, leading to 11.3% reduction of

² Ho Chi Minh City

electricity consumption compared to 2019. This is the reason why we chose 2019 as the base year for this study to reflect the actual image of electricity consumption of the university without the pandemic. Moreover, we can observe that April and October are the two months that have highest electricity consumption since these are the examination months where more students gather at the campus; and August has the lowest electricity consumption since this is the summertime where only several summer classes are held.

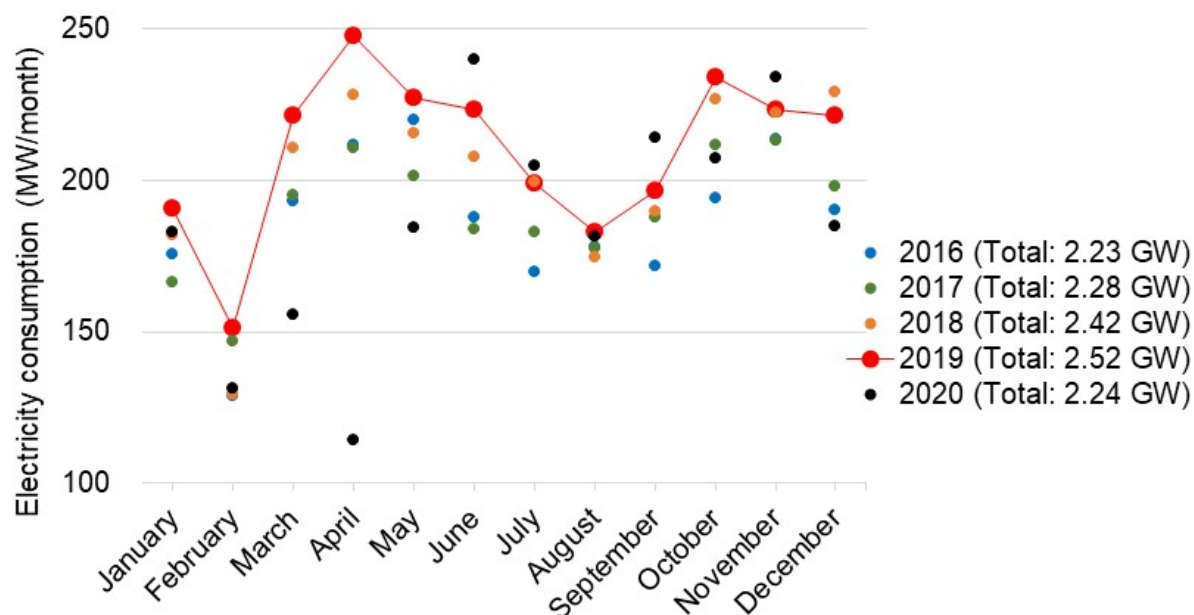


Figure 2. Total Electricity Consumption in IU-VNU

Body

Several methods for analyzing energy consumption in educational campuses are reviewed and compared. A framework is conducted by Koo et al. (2014) to analyze the effect of energy-saving techniques at the current point as well as in different scenarios at the future point for selected educational facilities. However, this study only focuses on three energy-saving techniques for three services: space heating and cooling, lighting, and room electricity. Besides, the optimization process using a genetic algorithm only considers the financial aspects (initial investment cost, net present value, and saving-to-investment ratio). On the other hand, Ascione et al. (2017) study the role of cost-effective refurbishment through a multi-step and multi-objective optimization in calibrated numerical models. This study expands the consideration to not only costs, incentives, indoor comfort, but also energy demands for heating and cooling. However, the proposed methodology is not user-friendly since it requires expertise in building energy modelling as well as in the implementation of the employed optimization algorithms.

In term of GHG mitigation, a more general framework for the assessment of carbon footprints along with overall sustainability in educational campuses is developed by Jain et al. (2017). A broader view is considered based on experts' opinion and literature review in weighting and scoring twenty-four indicators that cover four components of sustainability. The framework is applied for TERI University (New Delhi, India) and show the result on annual emissions per capita. This is important for the comparison with other universities to encourage the emission reduction within the campuses. Nevertheless, the role of technology aspect is not described in detail. In contrast, Ocampo Batlle et al. (2020) developed a method

to estimate baseline energy use and quantify savings in electrical energy consumption by taken into account types of activities carried out in the building, weather conditions, building materials, air conditioning system and occupancy. The results on energy savings potential, GHG emission reduction and economic benefit are extensive for a university towards sustainable existence.

AIM/Enduse Model

In this study, we try to bridge the methodological gaps of previous studies and obtain aforementioned results for IU-VNU. AIM/Enduse model (Hanaoka et al. 2015) is used to calculate the level of electricity consumption as well as CO₂ emissions in A1 and A2 buildings if IU-VNU main campus with distinct scenarios: base year 2019, 2030baseline and 2030mitigation scenarios. The difference of two scenarios for 2030 is the share of using technologies, which means that the transfers from conventional to advanced technologies are assumed in IU-VNU buildings in the near future so as to reduce the energy consumption and mitigate the CO₂ emissions.

The AIM/Enduse model, developed by National Institute for Environmental Studies (NIES) in Japan, is an optimization linear programming approach with detailed technology selection framework within an energy-economy-environment system. This is a bottom-up approach considering not only the financial aspects (costs of technologies, energy price, taxes and subsidies) but also technical aspects (service demands, lifetime, share of technology diffusion) as well as market availability of the technology (stock quantity). There are excel files for data input and output as a user-friendly platform instead of running the AIM/Enduse model via General Algebraic Modeling System (GAMS) program.

The main function for cost optimization is shown in Eq.1, followed by various constraints such as service demand (Eq.2), stock dynamics (Eq.3), emission quantity (Eq.4 and Eq.5), energy supply (Eq.6 and Eq.7), and service share (Eq.8 and Eq.9).

$$\begin{aligned} \text{Total cost} = & \text{Initial investment cost (\$)} + \text{Operating and maintenance cost (\$/year)} \\ & + \text{Energy cost (\$/year)} + \text{Payment for energy tax (\$/year)} + \text{Payment for} \\ & \text{emission tax (\$/year)} \end{aligned} \quad (\text{Eq.1})$$

$$D(j) \leq \sum_l A(j, l) * X(l) \quad (\text{Eq.2})$$

where:

$D(j)$: Service demand quantity of service type j

$A(j, l)$: Output of service j per unit operation of device l

$X(l)$: Operating quantity of device l

$$S(l) = \bar{S}(l) * \left(1 - \frac{1}{T(l)}\right) + r(l) - w(l) \quad (\text{Eq.3})$$

where:

$S(l)$: Stock of device l

$\bar{S}(l)$: Stock of device l in the previous year

$T(l)$: Lifetime of device l

$r(l)$: Recruited quantity of device l

$w(l)$: Retired quantity of device l

$$Q(m) = \sum_l X(l) * e(l, m) \quad (\text{Eq.4})$$

$$Q^m(m) \leq \widehat{Q}(m) \quad (Eq.5)$$

where:

$Q(m)$: Emission of gas m

$e(l, m)$: Emission of gas m per unit operation of device l

$\widehat{Q}(m)$: Maximum limit on emission of gas m

$$E(k, l) * X(l) \leq \widehat{E}^{max(k)} \quad (Eq.6)$$

$$E(k, l) * X(l) \geq \widehat{E}^{min(k)} \quad (Eq.7)$$

where:

$E(k, l)$: Energy use of energy k per operating unit of device l

$\widehat{E}^{max(k)}$: Maximum supply quantity of energy k

$\widehat{E}^{min(k)}$: Minimum supply quantity of energy k

$$\theta^{max}(j, l) * \sum_{l'} A(j, l') * X(l') \geq \sum_l A(j, l) * X(l) \quad (Eq.8)$$

$$\theta^{min}(j, l) * \sum_{l'} A(j, l') * X(l') \leq \sum_l A(j, l) * X(l) \quad (Eq.9)$$

where:

$\theta^{max}(j, l)$: Maximum share of device l in service j

$\theta^{min}(j, l)$: Minimum share of device l in service j

Data Collection and Assumptions

Due to the data availability, this study only focuses on electricity audit and electricity related CO₂ inventory and projection. The end-use electricity consumption is necessary to discover the energy savings potential when technological change is implemented. In buildings and facilities, the main electricity consumption services are elevation, lighting, water heating, space cooling, refrigeration, office equipment, laboratory equipment, miscellaneous.

In the current seven-floors A1 and A2 buildings, there are forty-four classrooms, sixty-two administrative offices, sixty laboratories, two libraries, four food courts and one separated canteen that provides services for nearly five hundred staffs and faculties as well as more than nine thousand students. Table 1 shows the current status of facilities and devices in IU-VNU with total electricity consumption capacity.

Facility	Device/Area	Quantity	Unit	Unit capacity (kW)	Total capacity (kW)
Elevation	Elevator	8	elevator	7.5	60.0
Laboratory	Equipment	60	lab.	20.0	1,200.0
Classroom	50-seats	24	room	2.0	48.0
	90-seats	12	room	2.2	26.4
	150-seats	4	room	2.8	11.2
	170-seats	4	room	3.0	12.0
Office room	30m ²	30	room	2.5	75.0
	60m ²	22	room	4.0	88.0
	93m ²	10	room	6.0	60.0
Library	1,160m ²	2	room	5.0	10.0
Lobby	Light	1,500	light	0.009	13.5
	Water heater	28	heater	1.0	28.0
Streetlights	Lights	35	light	0.1	3.5

Space cooling	Air conditioner	319	air conditioner	2.4	780.0
Others	Pumps	-	pump	20.0	20.0
Total					2,425.6

Table 1. Number of Facilities and Devices in A1 and A2 Buildings of IU-VNU in 2019.

Based on the total electricity consumption in 2019 (as shown in Figure 2) and the list of electricity service demand (as summarized in Table 1), a breakdown of electricity consumption by service is conducted for IU-VNU and is compared with other university's electricity consumption structure (as shown in Table 2). For universities located in tropical regions, the largest electricity consumer is air conditioning. Therefore, it's necessary to discover the energy savings potential in this service, especially under the context of warming climate that leads to increasing cooling demand.

Service	Electricity consumption structure (%)			
	IU-VNU (2019)	National Autonomous University of Mexico (Escobedo et al. 2014)	City University of Hong Kong (Yeo et al. 2019)	Universiti Malaya (Birkha Mohd Ali et al. 2021)
Lighting	0.4	33.6	34.5	18.0
Air conditioning	67.9	4.4	32.3	34.0
Computer equipment	9.4	4.9	-	10.0
Lifting	1.7	-	-	7.0
Refrigeration	-	16.9	-	6.0
Laboratory equipment	19.1	15.2	14.5	18.0
Miscellaneous	1.4	4.1	18.7	7.0
Motors	-	2.3	-	-
Space heating	-	0.4	-	-

Table 2. Electricity Consumption Structure by Services in Educational Buildings

To discover the potential of energy savings and GHG emission mitigation in IU-VNU, three scenarios are developed with different assumptions, especially for the future projections. The 2030baseline scenario measures the level of consumed energy and GHG emissions with the existing technologies and the 2030mitigation scenario with the replacement to advanced technologies in target year 2030. In 2030baseline scenario, there is assumption that the share of electricity-intensive equipment will decrease in 1% -20% of usage, and the electricity-saving devices are assumed to be increased at the same rate. In addition, in 2030mitigation scenario additional replacement of conventional technology will be added with 3-35% more than 2030baseline's level, even with the elimination of some conventional devices. Table 3 summarizes the value of main parameters to be inputted in the AIM/Enduse model for the calculation.

Parameter	Unit	Value			Explanation
		2019	2030 baseline	2030 mitigation	
Emission tax	USD	0	0	50	Only applied for mitigation scenario to consider measures towards emission reduction, for the cost optimization in Eq.1
Energy tax	USD	0	0	50	
Technology discount rate	%	33	33	33	For the annualization of investment cost in Eq.1 (assume average 3-year payback period for technology investment) (high discount rate)
Emission factor	tCO ₂ eq /toe	5.5	5.2	5.2	Emission factor of electricity generation in 2019 is declared by the Climate change department of Vietnam. In 2030, Vietnam increases the contribution of renewable energies in power generation structure, thus we assume the emission factor will be lower.
Electricity price	1,000 USD/toe	0.51	0.77	0.77	Electricity price in 2019 is based on the actual price (0.08 USD/kWh). In 2030, the price is estimated to increase 1.5 times compared to 2019.
Total electricity service demand	toe	2,571	3,857	3,857	Service demand in 2019 is based on the actual demand. In 2030, the service demand is estimated to increase 1.5 times compared to 2019 to follow the increasing trend.
Device share	%	Based on actual calculation	Reduction of conventional technologies		Total share of devices for each service is 100%. There is increasing share

of advanced (high-efficient) technologies for the replacement of conventional technologies.

Table 3. Assumptions of Main Parameters in AIM/Enduse Model for IU-VNU

Electricity Consumption

Under the increasing service demand in space cooling, laboratory equipment, office equipment, lighting and others, the electricity demand for these services also increases relatively (as shown in Figure 3). The main electricity consumption services are space cooling, laboratory equipment and office equipment, with the increasing level in 2030 is 1.5 times compared to 2019.

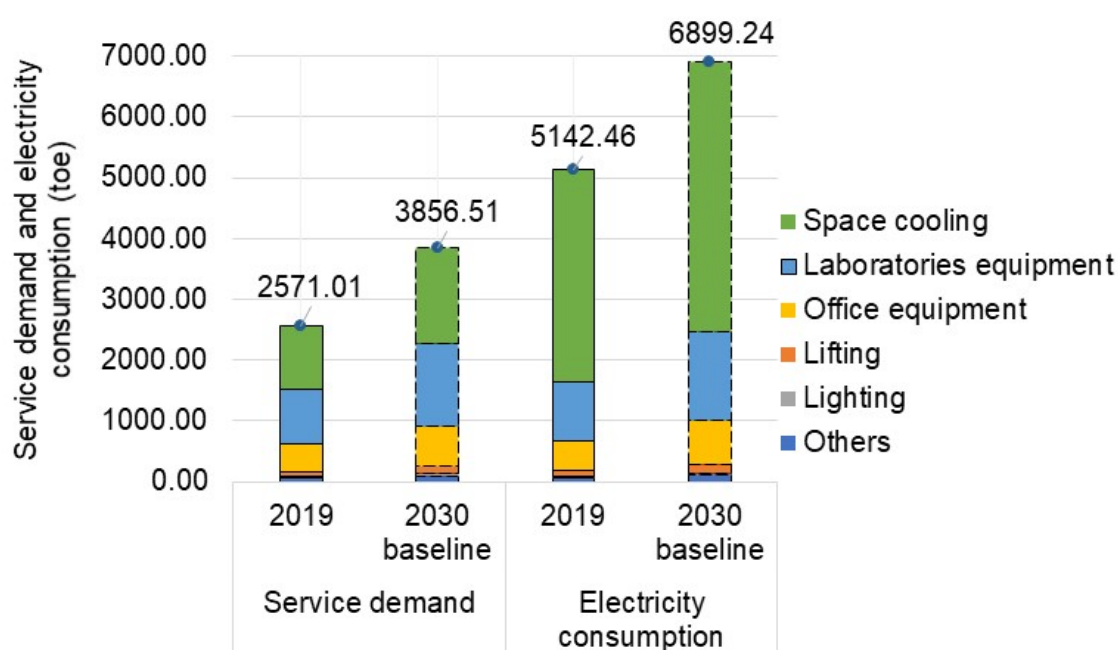


Figure 3. Service Demand and Electricity Consumption

The total electricity consumption in 2019 is 5,142.46 toe with the highest consumption comes from space cooling with 3,493.87 toe (67.9%) and the smallest consumed amount is lighting with 19.83 toe (0.4%). The second and the third highest electricity consumption are laboratory equipment and office equipment with the figures of 984.37 toe and 485.72 toe, respectively. In 2030baseline, the main electricity consumers are still space cooling, laboratory equipment and office equipment with 1.2 – 1.5 times higher than 2019. Under the assumption of device replacement from conventional to advanced technologies, the electricity consumption in 2030mitigation is reduced 13.0% compared to 2030baseline. Detail of electricity consumption by services in different scenarios are described in Table 4.

Service	2019	2030 baseline	2030 mitigation	2030baseline/2019	2030mitigation/2030baseline
Space cooling	3,493.87	4,426.35	3,523.89	1.27	0.80
Laboratory equipment	984.37	1,476.55	1,476.55	1.50	1.00

Office equipment	485.72	728.58	728.58	1.50	1.00
Lifting	88.15	132.23	132.23	1.50	1.00
Lighting	19.83	29.75	29.75	1.50	1.00
Others	70.52	105.78	105.78	1.50	1.00
Total	5,142.46	6,899.24	5,996.78	1.34	0.87

Table 4. Electricity Consumption by Service in Three Scenarios (toe)

CO₂ Emissions

Among the services, space cooling is the largest electricity consumer, and thus the biggest emitter compared to other services. Besides, this is the only service that has the potential of electricity savings as well as emission mitigation that contribute to the reduction potential of IU-VNU. With 20% reduction of electricity consumption in space cooling service, it helps to reduce 13% of total electricity consumption in IU-VNU and leads to 13% reduction of CO₂ emissions. Detail of CO₂ emissions by services in different scenarios are presented in Table 5. In which, space cooling is the biggest emitter with 67.94% of total emissions, followed by laboratory equipment and office equipment with 19.14% and 9.45% contribution, respectively. The remaining services (including lifting, lighting and others) contribute 3.47% of total emissions in IU-VNU.

Service	2019	2030 baseline	2030 mitigation	2030baseline/ 2019	2030mitigation/ 2030baseline
Space cooling	19,151.76	23,017.00	18,324.21	1.20	0.80
Laboratory equipment	5,395.84	7,678.06	7,678.06	1.42	1.00
Office equipment	2,662.48	3,788.61	3,788.61	1.42	1.00
Lifting	483.21	687.59	687.59	1.42	1.00
Lighting	108.72	154.71	154.71	1.42	1.00
Others	386.57	550.07	550.07	1.42	1.00
Total	28,188.57	35,876.03	31,183.25	1.27	0.87

Table 5. CO₂ Emissions by Service in Three Scenarios (tCO₂eq)

Contribution of Technology Change in the Reduction of Electricity Consumption and Co₂ Emissions

In each service, we assumed that there are conventional and advanced devices available in the stock for the AIM/Enduse model to select. The selection is based on the actual specification of the devices including their lifetime, costs, electricity intensity as well as the assumption of their shares for the contribution to meet the service demand. Generally, in 2030baseline scenario we assumed that the share of electricity-intensive devices will be reduced 1%-20% compared to 2019 as the tendency of replacing end-of-lifetime devices by the new devices that are available on market, in which the new devices will be more energy-efficient than the old ones. Moreover, in 2030mitigation scenario this reduction will be 3%-35% added, assuming that IU-VNU will actively replace old devices that highly consuming electricity with electricity-saving devices even though those old devices are still workable. Under this assumption, there will be some old devices that will be completely eliminated and replaced by newly advanced technology.

Particularly, for space cooling, which is the service that has the highest potential of energy savings as well as CO₂ mitigation, the centralized electricity-intensive 2-piece air conditioners will be replaced by decentralized electricity-saving air conditioners and steam fans with lower electricity consumption. The switch from centralized to decentralized operation will promote the role of end-users in controlling the devices.

Besides, in office equipment, 2030 mitigation scenario assumes that IU-VNU uses electricity-saving printers and photocopies whereas continue using several types of electricity-intensive devices. However, the university is planning to establish a central printing and copying room where most of the printing works will be done in this room to increase the effectiveness of this service for the whole university, instead of the current status where administrative and faculty offices have their own devices. Another service where technology change can be implemented is lighting. Currently, the fluorescent lamp consumes more than 50% compared to LED lamps; therefore, the replacement of the fluorescent lamp by LED lamps is necessary to increase the electricity savings potential in this service. In contrast, lifting service may not have technology change since the elevators were installed permanently.

The Role of End-Users in Electricity Saving

From the analysis of technology contribution, we could realize the importance of end-users in reducing the electricity consumption, especially in the services where technology change is difficult to be implemented. Therefore, an online survey was conducted with the targeted group is students at IU-VNU since this is the largest group of electricity users. Nearly five hundred students from different batches answered the questions related to the frequency of using electricity, type of devices, duration and purpose of usage as well as their opinion on the electricity saving actions within the campus.

In student's evaluation on the usage frequency of electrical equipment, air conditioners are the most used equipment with 94.46%, followed by lighting equipment with 87.30% in an average time of using from 2 up to 5 hours per day. Public electricity networks (electrical sockets along the corridor) with 69.28%, laboratory equipment with 23.56%, office and auditorium with 21.71%, which are rarely used in an average usage less than 2 hours. There is difference in the percentage of consumption between student's evaluation and electricity audit. For instance, the laboratories equipment is continuously operated day by day, so in the technology aspect the energy consumption of those equipment is a large amount. However, as the students use the equipment only in their lecture time, the frequency for using laboratory equipment is low in their evaluation.

In general, the use of electrical equipment mainly serves the learning purposes, so the energy consumption of the students' activities are considered to be a reasonable amount. The consumption of laboratories equipment is uncontrollable as the frequency of usage not only in office hours but also during nighttime.

Conclusions

The electricity consumption structure of IU-VNU is analyzed to discover the electricity savings and CO₂ mitigation potential in 2030, especially in space cooling service that consumes electricity the most. The technology transfer from conventional to advanced devices will bring energy efficiency as well as environmental and economic benefits. Under the assumptions in this study, IU-VNU can achieve 13% reduction of electricity consumption

as well as CO₂ emissions, that lead to nearly 1.5 billion Vietnam Dong (nearly 70,000 USD) savings annually. This saving money can be used for replacement of conventional to advanced energy-saving devices. Moreover, consumer behavior change, particularly in students, will greatly contribute to the success of electricity saving actions within the campus. Since IU-VNU is constructing a new building (namely A3), the findings in this study will be useful for the selection and installation of devices, especially for air-conditioners and office equipment when A3 building will become administrative building and A1-A2 buildings will be for classrooms and laboratories.

This study remains several limitations due to the lack of information for all electrical devices used in IU-VNU campus (such as at canteen and parking lots). Moreover, the availability of devices in the stock market for 2030 and the share of devices is subjectively assumed. Therefore, In terms of data uncertainty associated to CO₂ emissions, we can refer to the method and reference from IPCC (International Panel on Climate Change 2019), in which the average uncertainty for electricity consumption and related emission factor is 18%.

This study suggests that university should have annual energy audits for all activities within the campus, with the installation of smart meters at various points. Moreover, a record of all electrical devices with detail specification should be kept and updated frequently. In addition, a participatory planning process (integrating end-users such as faculty, staff, and students) should also be implemented to increase consumer's awareness and engagement in reducing energy waste towards sustainable energy-use campus. Since the solar energy is having incentives from the Vietnamese government, it's worth noticing that IU-VNU may install the roof-top solar panels to reduce the electricity dependence on grid power.

Acknowledgements

The authors would like to acknowledge the data provision from the Office of Facility Development and the Office of Procurement Services in IU-VNU.

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