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Landscape change analysis: Ecosystem services in the peri-urban agriculture of Bangkok

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Abstract

Over the past decades, the Bangkok peri-urban area has been transformed from agricultural villages to urban development communities. Considering the flat terrain and poor drainage of the Chao Phraya lower floodplain, peri-urban agriculture consists of patches that create and add ecosystem services and values for the mega urban area. The significant loss of the agricultural landscape as part of peri-urban Bangkok means a potential loss of seasonal water retention areas, productive landscapes, as well as habitat for urban wildlife. This research classifies and analyzes landscape transformations especially agricultural landscape structure and functions of eight sites surrounded by the urban fringe of Bangkok: 1) Rangsit, Pathum Thani; 2) Bang Kradi, Pathum Thani; 3 Khlong Hok Wa, Pathum Thani; 4) Lat Krabang, Bangkok; 5) Bangplee, Samut Prakarn; 6) Khok Kham, Samut Sakhon; 7) Tha Mai, Samut Sakhon; and 8) Mahasawat, Nakhon Pathom. By tracing landscape change patterns for these sites between 1952 and 2018, the results show a significantly increasing percentage of built up area especially to the north of Bangkok. This urbanization trend is directly related to the decreasing percentage in green space. However, based on per cent coverage, the water patterns seem to be the only landscape element which is not changing in relation to urbanization, although seasonally and through time, the patterns of agricultural cut and fill irrigation storage has changed. The study highlights the challenge of land transformation and water management due to the loss of peri-urban wetlands. An approach to promote ecosystem services linking to the preservation and focus on the peri-urban agriculture landscape of Bangkok Metro Regions is proposed.

Keywords

Peri-urban agriculture; Landscape change; Bangkok Metro Region; Chao Phraya lower floodplain; Ecosystem services

1. Introduction

Rapid urbanization without effective land use planning seems to be the common development trend associated with environmental and ecological concerns in South East Asian cities. Most of these cities are situated in low-lying floodplains and the edges of the cities which used to be agricultural landscape have been transformed rapidly towards mixed land use areas combining both rural and urban activities. The ecological functions and ecosystem services provided by the peri-urban agriculture landscape are key elements that support multifunctional service opportunities for the urban development (Groenfeldt, 2006; OECD, 2015; Suwanarit, 2017). Bangkok, situated in the lower part of the Chao Phraya floodplain, has been recognized as a city with high flood risk (Thaitakoo & McGrath, 2008; Marome, 2013; OECD, 2015). Protecting and maintaining the agricultural landscape, which could provide ecological functions and services to the cityscape, is of crucial significance to increasing the region's resilience to floods, food security, and other disruptions. The weak controlling policies and regulations, poor communications and collaborations between government agencies, and the absence of strong linkages to social engagement through the spatial planning process, have resulted in the Bangkok Metro Region (BMR) becoming a large metropolitan area faced with considerable risks and urban issues (Pradhan & Perera, 2006; Hara et al., 2008; Marome, 2013; OECD, 2015; Suwanarit, 2017). Since paddy fields are the most transformed ecosystems of the newly urbanized areas (Hara et al., 2008; Thaitakoo et al., 2012; Suwanarit, 2017), the fragmented patterns of existing agricultural landscapes are abandoned, replaced with new urban developments; i.e. roads, highways, housing estates, and factories.

In South East Asia, most of the studies on urban ecosystem services of blue-green infrastructure have been reported for Singapore, while only a few works on the topic are found for other mega cities, including Bangkok, Kuala Lumpur, and Jakarta (Lourdes et al., 2021). The study of Loc et al. (2020) that identified the barriers and bridges of mainstreaming ecosystem services as public policy in South East Asia highlighted the barrier of fragmented mandates between policy makers and capital, especially for Phnom Penh and Bangkok. The study also suggested ways forward to better incorporate ecosystem service concepts into the public policy arena. Jongkroy (2009) examined landscape settlement pattern changes in peri-urban Bangkok from 1988-2007 and classified the urban settlements into four categories: i) clustered settlement patterns in primary urban centers; ii) radial settlement patterns around provincial centers; iii) linear settlement patterns along road networks and rivers; and iv) scattered pattern. The most highly developed areas are in Nonthaburi, Pathum Thani, and Samut Prakarn. The pattern of urban development in the peri-urban fringe usually results in ecological problems, especially in association with runoff water draining to the irrigation canals (Kritsanaphan & Sajor, 2011). In addition, the new urban development of the fringe experiences localized flooding due to the poor drainage terrain and management (Limthongsakul et al., 2017). New forms of urban design related to this urban expansion should be introduced by considering the ecosystem characteristics of the area (Nasongkhla & Sintushigha, 2010; Mc Gee & Saharudin, 2016; Loc et al., 2020). The study of Anwar and Borne (2005) on change of land-use dynamics between 1981 and 2000 in Nong Chok, located in the western part of Bangkok, defined landscape patterns into five characteristics: i) paddy fields, ii) fish ponds, iii) residences and orchards, iv) waterbodies, and v) other. There is a conflict between the existing agricultural land-use and the new form of urban development. Sahavacharin and Likitswat (2019) examined the ecological structure of peri-urban agriculture in the fringe of Bangkok and identified seven patterns of peri-urban agriculture landscape characteristics. The study suggested guidelines to promote ecosystem services within peri-urban development, which included: i) maintaining quality peri-urban agricultural areas and development of potential green spaces;

ii) suggesting other forms of peri-urban agriculture; and iii) suggesting a model for urban development. The work reported herein emphasizes the research gaps in the study of landscape dynamics and ecosystem services of peri-urban Bangkok and suggests an opportunity for linking this concept to local policies for maintaining the ecological function of peri-urban agricultural areas.

This paper explores and analyzes the patterns of fragmented patches and landscape change within 20-30 kilometers from the center of Bangkok to understand the patch dynamics of lower Chao Phraya floodplain. It also redefines and links agricultural functions of peri-urban Bangkok with ecosystem services. The study identifies alternative ways for designing agricultural landscapes, which link to ecosystem services (ES). Challenges were identified for implementing sustainable landscape management, which ultimately act as barriers for mainstreaming consideration of ES in policies and practices.

2. Materials and Methods

2.1 Mapping landscape changes

There were two mapping scales used to identify changes in the landscape structure of peri-urban Bangkok. Macro scale mapping was used to read the present landscape pattern and frame the selected micro scale study areas (Figure 1).

Figure 1 Satellite image and micro study area boundaries for peri-urban Bangkok.

Figure 1 illustrates the 25 km^2 boundary of each peri-urban Bangkok study area. Eight micro scale study areas were included for consideration, Area 1: Rangsit Khlong Sam and Khlong Si; Pathum Thani Area 2: Bang Kradi, Pathum Thani; Area 3: Lum Lukka Khlong Hok Wa, Pathum Thani; Area 4: Khlong Chorakhe Noi and Khlong Lat Krabang, Bangkok; Area 5: Bangplee, Samut Prakan; Area 6: Kok Kham, Samut Sakhon; Area 7: Tha Mai, Samut Sakhon; and Area 8: Khlong Mahasawat, Nakhon Pathom.

For the macro scale mapping, 1990-2010 Landsat and 2015 SPOT satellite images were processed using ArcGIS base maps combined with the geographic information from the Bangkok GIS Centre (http://www.bangkokgis.com/modules.php?m=download_shapefile). For the micro scale studies, the series of aerial photographs from the Royal Thai Survey Department and Google Map for the periods 1952, 1973, 1976-1977, 2002, and 2017-2018 were used to classify and understand changes in the peri-urban Bangkok landscape. From raster aerial photographs, visual interpretations were used to convert to vector files and analyze the percentage of each landscape component. The landscape structure changes within 25 km^2 of eight study areas from the four quadrants of BMR were assessed, following the procedures discussed below. The north-east quadrant includes Area 1, Area 2, and Area 3. The southeast quadrant includes Area 4, and Area 5. The southeast quadrant includes Area 6, and Area 7. Lastly, the only study area in the north-west quadrant is Area 8. These micro study areas were defined as polygons with dimensions of 5 km north – south, and 5 km east – west (25 km^2 for each study area).

Since the old aerial images were taken during different seasons, there may be some variations and errors in classification and interpretation. Also, the surveys and observations of particular study areas were explored from 2016 to 2017. To translate and understand the local circumstances from the ground, we combined a computerized image analysis process with the interpreted satellite imageries and aerial photographs. The built-up areas, waterbody and green area were interpreted using a supervised maximum likelihood algorithm and visual interpretation with manual classification refinements to identify the spatial features in the landscape.

2.2 Methods

The methods were separated into two steps as shown in Figure 2. The first step was to classify and analyze the landscape structure and changes over time to understand the patch dynamics of peri-urban Bangkok. Microscale mapping was involved in this process to understand the landscape patterns and changes of peri-urban Bangkok in the selected study areas. Figure 3 is generated by overlaying vector layers from raster image through onscreen digitization process. Based on the studies of Anwar (2005) and Jongkroy (2009), we combined and simplified the landscape patches into three categories: i) built up areas; ii) water systems; and iii) green areas. The second step was to discuss the peri-urban landscape dynamics in the context of ecosystem functions and services. By understanding the trend of ongoing development sprawl over the existing agricultural landscape, we can draw a relationship between ecosystem function and ES benefits. This research aims to highlight the linkage between the landscape dynamics of peri-urban Bangkok and ES concepts.

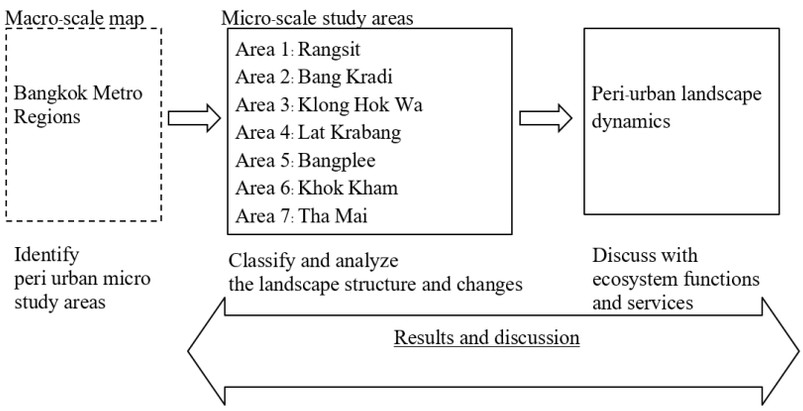

Figure 2 Methodology diagram mapping the study flow.

3. Results and Discussion

The landscape transformation and dynamics and the linkage to ES are discussed in this study. Land cover, ecosystem types, ecological functions, and structures of the study area were mapped and interpreted to understand the landscape dynamics and changes over the past decades. The study also focused on the remaining water systems and green areas included with the agricultural landscapes. These agricultural patches are highly dynamic with non-linearity characteristics during the wet and dry seasons. This section will be divided into three main topics: landscape transformations and changes, fast developing built up areas over wet landscape mosaics, and linking function of peri-urban agricultural landscape to ES concepts.

3.1 Landscape transformations and changes

In the eight selected study sites, the three layers of land coverage included built up areas, water systems, and green areas. Within the 25 km^2 study sites, the percentages of peri-urban landscape changes were interpreted and estimated for the period 1952 to 2017, as summarized in Table 1. Built up areas include households, factories, road networks and polders. Water systems include rivers, canals, ponds, and some paddy waterscapes. Green areas include agricultural landscape, abandoned lots, and green open spaces.

Table 1 Peri-urban landscapes change analysis within the 25 km^2 study areas.

Area	Year	Built up areas	Water systems	Green areas
1 Rangsit, Phathum Thani	1952	3%	13.5%	83.5%
	2002	15.5%	10%	74.5%
	2017	40%	13%	47%
2 Bang Kradi, Phathum Thani	1952	1%	12%	87%
	2004	25%	10%	65%
	2017	65%	7%	28%
3 Klong Hok Wa, Phathum Thani	1952	1%	12%	87%
	2002	5%	10%	85%
	2017	12.5%	15%	72.5%
4 Lat Krabang,Bangkok	1952	2%	4.5%	93.5%
	2002	10.5%	9.5%	80%
	2017	15%	15%	70%
5 Bangplee, Samut Prakan	1952	1.5%	48.5%	50%
	2002	4%	50.5%	45.5%
	2017	10%	60%	30%
6 Khok Kam, Samut Sakhon	1952	3%	46.5%	50.5%
	2002	5%	48%	47%
	2017	10.5%	52.5%	37%
7 Tha Mai, Samut Sakhon	1952	0.5%	12.5%	87%
	1976	2%	14%	84%
	2017	4.5%	12.5%	83%
8 Mahasawat, Nakhon Pathom	1952	0.5%	13.5%	86%
	2002	4.5%	14%	81.5%
	2017	20%	12.5%	67.5%

The peri-urban Bangkok area of 1952 consisted of more than 95% water systems and green areas. Most of the areas were spongy and adaptive with the local monsoon climate. The landscape patterns between blue and green areas can fluctuate over particular periods or years. The examples of agricultural activities include rice paddies, orchards, aquaculture, and other agricultural activities. The structure and patterns of the water systems were different east and west of the Chao Phraya River. Most of the indigenous canal systems were found in Areas 6, 7, and 8, west of the Chao Phraya, while modern irrigation canals and systems were mostly found in Areas 1, 2, 3, 4, and 5, east of the river. These two drainage systems also influenced the surrounding shapes and sizes of the agricultural patches. Curvilinear indigenous canals lead to small and irregular shapes of agricultural patches, whereas the straight modern irrigated canals were related to large and rectangular linear patterns. Area 5 (Bang Plee) and Area 6 (Khok Kam) were covered with approximately 50% water surfaces.

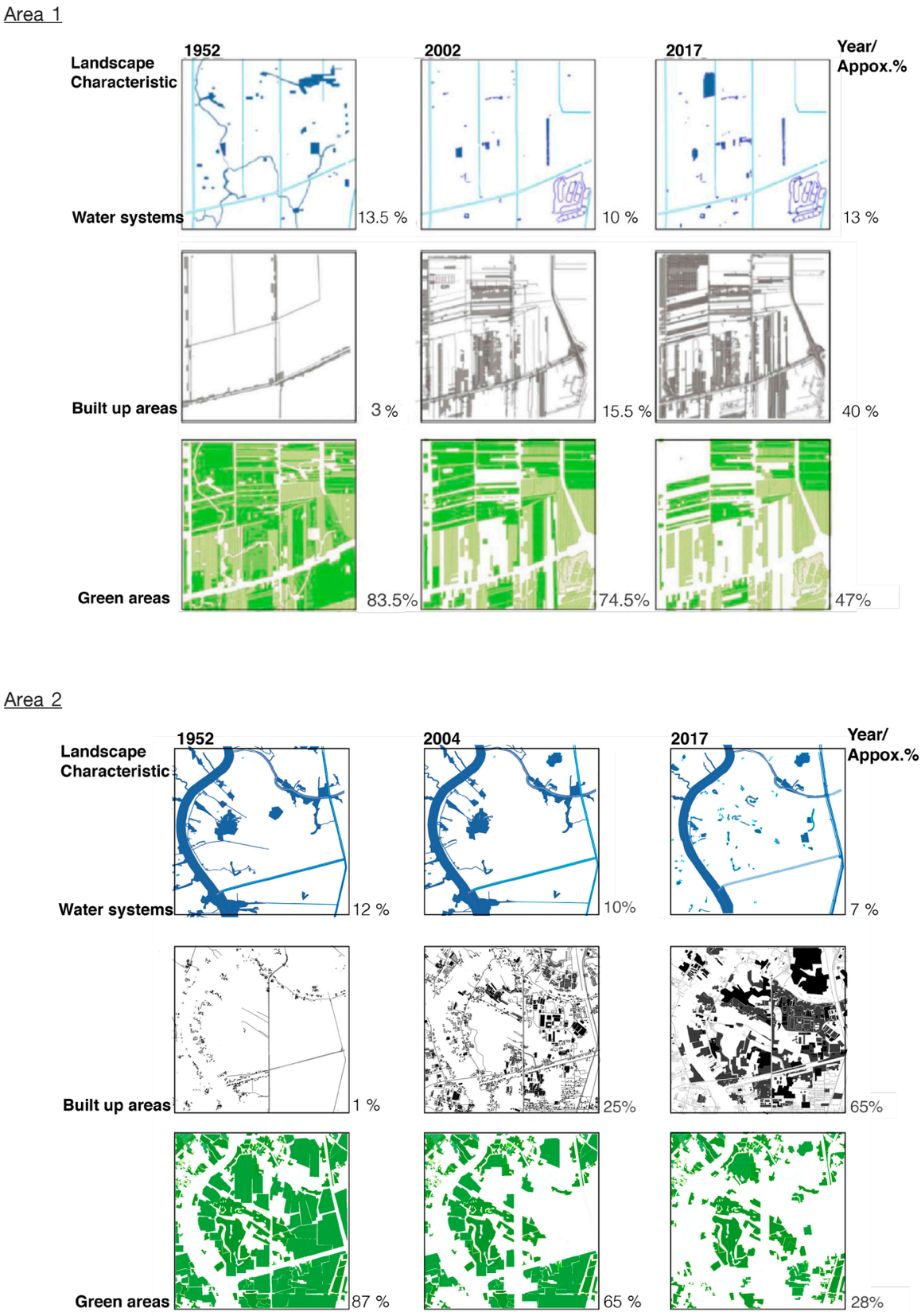

Figure 3 Mapping samples of landscape changes for Area 1 and Area 2.

Figure 3. illustrates the mapping samples of Area 1 (Rangsit) and Area 2 (Bang Kradi), the most fragmented and built up areas compared to other areas.

Over time, the peri-urban agricultural landscape of Bangkok has been exponentially transformed toward an urbanized land use in Area 2 (Bang Kradi) and rapidly in Area 1 (Rangsit). Due to the construction of industrial estates in Pathum Thani as well as pressures from the urban sprawl of Bangkok, both areas have been significantly transformed toward urban development with a small percentage of green areas remaining. Area 5 (Bang Plee) has faced the same developmental trends as Bang Kradi and Rangsit, with the development of industrial and residential zones in Samut Prakan. Even though water surface used to cover almost half of Area 5, building continued on the wet ground. The only remaining green areas were found in Area 7 (Tha Mai) and Area 4 (Lat Krabang). Keeping the characteristic of the wet landscape in peri-urban agricultural Bangkok, these two areas were slowly transformed, compared to the other six cases.

The water systems are highly dynamic during the wet and dry season. The development processes were also involved with landform transformation by cutting and filling dirt, soil, and substrate materials. Big ponds and higher ground levels become the new characteristic of the global way of developing the city on the existing wet landscape. This process of land transformation is not a sustainable way of development without control and monitoring (Waldheim, 1999; Thaitakoo & McGrath, 2008; Thaitakoo et al., 2012). The mapping of macro and micro scale landscape changes of peri-urban Bangkok showed that the characteristic of the flood plain delta remained with a high percentage of water surfaces and green areas (although the percentage of green area generally declined over time).

3.2 Fast developing built up areas over wet landscape mosaics

The result shows an increasing percentage of built-up areas in peri-urban Bangkok. Unlike the clustered settlement pattern, which is usually found in the inner city of Bangkok (Jongkroy, 2009), the landscape settlement pattern changes in peri-urban Bangkok can be defined as radial settlement patterns around provincial centers, linear settlement patterns along road networks and rivers, and a scattered pattern. For example, in Figure 2, Area 1, the Rangsit built-up area in 1952 was characterized by small residences along the canals. In 2002, after the development of the Kanchanapisek ring road, the characteristic built-up areas changed to a mix of both linear settlement patterns along road networks and canals and a scattered pattern. The developing built-up areas in 2018 showed a fast growth and new cluster. The other example of a fast developing area is shown in Area 2 (Bang Kradi). The percentage of built-up area was 1% in 1952, 25% in 2004, and 65% in 2007. It is clear that the pattern of urbanization can be defined as a mix of both linear settlement patterns along the Chao Phraya River and road networks as well as a scattered pattern in relation to industrial estates. From the landscape transformation and change analysis of the eight studied areas, we found fast development of the built-up area in the northern part of Bangkok, especially in Area 2, Bang Kradi.

Area 1 (Rangsit), Area 2 (Bang Kradi), and Area 3 (Klong Hokwa) are situated in the administrative boundary of Pathum Thani. Following 2015, the land use zoning of Pathum Thani was controlled to be Rural and agricultural zones. Eventhough Area 3 Klong Hok Wa is designated as Rural and agricultural zones, it differs from Area 1 (Rangsit) and Area 2 (Bang Kradi), both of which were allowed to develop residential areas mixed with industrial and warehouse zones. From the field observations, sprawling patterns of urban factories could share some similarities between the other three cases based in Pathum Thani. Factories, warehouses, gated communities or new development forms were built on existing large parcels of paddy fields.

Area 4 (Lat Krabang) is situated on the political boundary of Bangkok Metropolitan Administration (BMA), in the areas of Low-density residential zone and Rural and agricultural conservation zone (from 2013 BMA Land Use Plan). Also, Area 5 (Bang Plee) shared similar land development on the east side of the Chao Praya River. These areas are supposed to act as water retention areas to prevent floods on the eastern side of Bangkok. These are the areas which are close to Suvarnabhumi Airport, previously known as Nong Ngu Hoa meaning Snake Lake in Thai.

Area 6 (Khok Kam), Area 7 (Tha Mai) and Area 8 (Mahasawat) are located in Samut Sakhon and Nakhon Pathom, and in proximity to the Tha Chin River, which is a sub branch of the Chao Phraya. Contrasting with the provincial land use zoning plan, which allowed the areas to develop as residential zones, most of the areas are still used for farmlands, ornamental plantations, and aquaculture activities, even though only a part of Area 6 (Khok Kham) is located in the Rural and agricultural zone of the 2017 Samut Sakhon Land Use Plan.

One of the challenges of developing and managing resources in this mega-city was caused by poor coordination and collaboration within the BMA and the five surrounding provinces (Marome, 2013; OECD, 2015; Suwanarit, 2017). Regarding the development of spatial planning, BMA adopted an approach that focused on the bulk control of building regulation, such as floor area ratio (FAR) and open space ratio (OSR), while the other five vicinities focus only on land use zoning plans. The new initiative for promoting more green open space was found in BMA (i.e., the Bangkok Metropolis 20 Years (2013-2032) Development Plan) or climate change initiatives (i.e., Bangkok Action Plan on Global Warming and Mitigating 2007-2012), and Master Plan on Climate Change (2013-2023), or land use and transport plan (i.e., Bangkok Comprehensive Plan 2013, and Mass Transit Network, Bangkok Comprehensive Plan 2013; OECD, 2015). The plan to develop and manage the vast metropolitan area of the BMR is done under the control of the central government (i.e., 2013 Bangkok and Vicinities Development Structure Plan). One example for managing the urban-rural infrastructures such as canals and water gates is the ineffective collaborations between BMA and the surrounding provinces. Fragmented urban fabric development is reflected by the weak coordination between government agencies and stakeholders to create and share resilience plans and policies toward sustainable development (Marome, 2013; OECD, 2015).

Land transformation in peri-urban Bangkok is not only changing the elevation of the flood prone area, but also runoff patterns around the city. The urbanization pattern changes lead to environmental problems especially on water systems, including localized flooding (Limthongsakul et al., 2017) and water pollution (Kritsanaphan & Sajor, 2011). Nasongkhla and Sintushigha (2010) and Mc Gee and Shaharudin (2016) suggested ways to reimagine the new form of urban expansion based on eco-system characteristics. In this case of peri-urban Bangkok, such reimagining would correspond to the nature of wet landscapes and flat terrains.

From the originally spongy landscape with its ability to absorb water seasonally, the new landscape of peri-urban Bangkok shares the characteristic of a global and international style of urbanization. The new built up areas are connected with fast movement, paved with hard surfaces and concrete, and sprawling with fragmented patterns and conditions. The functional existing canals have changed from irrigation channels and transportation corridors to catchment areas draining surface runoff from the new development areas. One of the challenges is how to manage water in this floodplain along with the fast urbanization movement. Understanding this dynamic growth of sprawl is necessary and linked to an appreciation for the loss of ecosystem functions and services. It is crucial to identify the benefits of ecological function of peri-urban agriculture.

3.3 Linking function of peri-urban agricultural landscape to ES concepts

As discussed above, the fast development, sprawling and spreading of built-up areas throughout peri-urban Bangkok may affect the wetland dynamic systems of peri-urban agricultural activities. Several studies on urban and peri-urban agriculture confirm the positive impact and multifunctionality of these green productive spaces (Smit & Nasr, 1992; Groenfeldt, 2006; Vagneron, 2007). The field observations on landscape structure were analyzed and discussed along with the patterns and landscape characteristics of the eight study areas, with a focus on the agricultural landscape mosaics. By evaluating available information and observing the study areas, there were four main landscape structures identified for agricultural usage, as summarized in Table 2.

Table 2 Landscape structure and peri-urban agriculture characteristics.

Rice paddy and related crops	Mixed orchard	Aquaculture	Others
Large patches and mono culture of rice field with chemicals used: Area 1, 3, 4	Mixed crops, vegetable, ornamental plants, and flowers, on Suan Yok Rong (Thai-Chinese way of farming): Area 2, 7	1-2 meters depth brackish water pond of fish, shrimp, and crab farms: Area 5, 6	High- tech farms: Area 1, 2, 3
Rice and lotus pond farming: Area 8	Mixed crops, Suan Yok Pleng (ridge farming): Area 7	Freshwater pond of fish and shrimp farms: Area 4	Solar farming on ridging systems: Area 6
Small patches of rice paddy combined with orchards and herbs on dikes: Area 8			

Table 2 shows the remaining dominant landscape structures and peri-urban agricultural characteristics. Four landscape structures were identified; rice paddy and related crops, mixed orchard, aquaculture, and other activities. The observations were conducted between 2016 and 2017.

The remaining landscape structure and mosaics ranged from the seasonal wet landscape of rice fields, corridors or patches of orchards surrounded with waterscape, fresh or brackish ponds, and the landscape characteristics that combined both cultural and natural activities and processes providing ecosystem functions and services (Sahavacharin & Likitswat, 2019). By mapping the functions of peri-urban Bangkok with ecosystem services principles, these remaining agricultural landscape patches capture multi-functional values and bring ecological and cultural benefits to the urban area. Table 3 explains how the ES framework could be linked to the peri-urban agricultural functions.

Table 3 Ecosystem services of peri-urban agricultural Bangkok.

Provisioning	Regulating	Supporting	Cultural
Urban food security, and reducing food distance to the city	Minimizes urban heat island impact/ cooling down the city	Facilitates augmentation and carbon sequestration	Urban green open space
Water supply during the dry seasons: fresh and brackish water ponds	Stormwater retention areas	Maintaining the ecosystem functions in the floodplain	Aesthetic values and preserving cultural landscapes
Source of alternative urban income			Urban or peri-urban wildlife habitats and sanctuaries
Genetic diversity			

Table 3 illustrates the ecosystem services of peri-urban agricultural Bangkok. [source: unpublished study by Likitswat & Sahavacharin, 2018]

Multifunctional landscape benefits link to ecosystem services of peri-urban agricultural Bangkok. The role of agricultural landscape patches is to provide ecosystem services in multiple dimensions. These blue and green infrastructures link directly to the provisioning, regulating, supporting, and cultural services. However, the pressure of the new developments has forced local farmers to adapt with the changing urbanized landscape. Either selling a section or complete lots, leaving the land, or finding new farming techniques with high value or high technology equipment, seem to be the alternatives to adapt with the development trends.

4. Conclusions

In summary, there is a strong connection between the blue and green patches and ES. From the landscape change analysis, we found benefits to the peri-urban agriculture landscape links with ES. To develop good practice on landscape transformations towards sustainable and resilient urban development, we should be critical about the ecological functions of existing landscapes. The peri-urban agricultural landscape provides opportunities such as food sources, stormwater retention, green open space, and urban wildlife habitat. New development trends should involve both socio-economic and ecological concerns to design multifunctional landscapes toward sustainable development. Either existing patterns or new landscape typologies should be complex with multifunctional purposes to serve ecosystem functions and services.

Within this manmade irrigated delta, the following sustainability issues need to be addressed: cultural heritage, ecological fragmentation, blue and green infrastructure, alternative ways of transportation, and urban and peri-urban agriculture. Urban and peri-urban agriculture landscapes provide ecosystem services to the city and bring resilience quality to newly urbanized areas (Sahavacharin & Likitswat, 2019). However, the concept of ES is still poorly recognized for developing urban planning policy and regulation in the BMR (Loc et al., 2020) but moving forward, should be linked to patterns of new urbanization forms that include consideration of these fragile ecosystems.

This study filled the research gap of understanding landscape dynamics and ecosystem services of peri-urban Bangkok. It is crucial to understand the limited conditions and changes of landscape patterns over time for decision-making on landscape planning and design in order to maximize ecological functions and services of existing agricultural ecosystems (Nassauer, 2008; Suwanarit, 2017; Thaitakoo et al., 2012; Vagneron, 2007; Waldheim, 1999; Wall, 1999). The aim is to build and raise awareness of sustainable challenges and new design approaches and perspectives for future generations. It is challenging to set the new standard of landscape design which can balance urban and natural characteristics for development and building sustainable landscape management plans and actions.

Our finding suggests that future research could link and develop a guideline for designing and developing projects focusing on water management, associated with the peri-urban landscape and activities. The study also provides the opportunity for linking this concept to local policies for maintaining the ecological function of peri-urban agricultural areas. The new form of planning for new urban expansion should be based on the ecosystem characteristics (Mc Gee & Shaharudin, 2016). The concept of aquatic culture and urban agriculture were suggested with the new form of urban development in Samut Prakarn (Nasongkhla & Sintushigha, 2010). With the new perspective and alternative way of development, an adaptive planning model considering the ecological function of the existing landscape is setting the new norm for design and living with the uncertainties of the future.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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Author Contributions

Conceptualization, F.L. and A.S.; methodology, F.L. and A.S.; validation, F.L. and A.S.; formal analysis, F.L. and A.S.; investigation, F.L. and A.S.; resources, F.L. and A.S.; data curation, F.L. and A.S.; writing - original draft, F.L.; writing - review & editing, F.L.; visualization, F.L.; supervision, F.L.; project administration, F.L.; and funding acquisition, F.L. All authors have read and agreed to the published version of the manuscript.

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