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Toward urban-rural linkage development: contribution of climate-adaptive agroecology in the lower Chao Phraya River Basin, Thailand

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This case study proposed a hypothesis on initiating urban-rural co-development using food as a medium to drive the transformation of the food systems and sustainable consumption. The guiding principles of the United Nations Habitat to the water-retention areas under the nature-based solution (NBS) for flood mitigation in Thailand's central region, the main rice-growing area, were applied. This study reviewed the partnerships of primary institutions, namely public, private, and universities, supporting and intertwining with civil society through Thai cultural and social norms after the 1997 economic crisis. The critical aspects included the sufficiency economy (SE) philosophy at the household level as a foundation of national policies. Recent policies and measures on food and nutrition security, alternative farming practices, and incentives to increase sustainable agroecology were prioritized post-COVID-19. This research suggests additional measures enabling agroecology and landscape improvement in rural areas connecting the cities of Ayutthaya and Bangkok to enhance market access for small producers and consumers in rural and urban areas with limited resources. A better community-based adaptation, ecological outcomes, and sustainable social inclusion in flood-prone lowlands could support Thailand's food sovereignty and capacity-building as one of the world's major food exporters under climate extremes.

KEYWORDS

agroecology, food systems, NBS, rice, SDGs, sufficiency economy

1. Introduction

The food system is a crucial factor driving societal culture, economy, and environment and is significantly affected by climate change. The direct impact of climate change on food systems involves seasonal temperature variations, heat, drought and precipitation patterns in each area (IPCC, 2014) that increase the likelihood of food insecurity. To address the complex challenges of ensuring food security and nutrition for a growing and rapidly urbanizing global population, we need the right tools to develop effective, sustainable, and socially-just policies (Dyball et al., 2021; Dyball, 2022). Besides, when designing food security and nutrition policies, it is essential to consider shock conditions such as disasters, epidemics, or wars on how to provide a consistent food supply, nutritious, culturally appropriate and reliable for the population for all food system actors: consumers, manufacturers, processors, distributors and retailers and farmers. Effective policymaking on complex food systems thus requires feedback analysis to understand the causes of systemic problems of the policy (Dyball et al., 2021).

Thailand is the world's leading producer and exporter of canned tuna, canned pineapple, frozen poultry, shrimp, rice, and cassava (Kittipanya-Ngam and Tan, 2020). However, the industrial production and agrochemical-based agri-food products in Thailand need to transform into sustainable agriculture and food system using an agroecology approach (FAO, 2017), which is an integrated approach that applies ecological and social concepts and principles to the design and management of food and agricultural systems (Barrios et al., 2020). This is because consumer demands, domestic and export, for safer and cleaner food produced through biodiversity- and environment-friendly agricultural products are increasing.

The primary agri-food production in Thailand is in the central region, where the farmers grow economic crops such as rice, sugarcane, pineapple and cassava. Livestock and aquaculture are also cultivated in central Thailand. Moreover, most of the cities at a provincial level and densely populated areas in the central plain of Thailand are located along the major rivers such as Phra Nakhon Si Ayutthaya (Ayutthaya in short), Pathum Thani, Nonthaburi, Bangkok and Samut Prakan provinces on the Chao Phraya River and Suphan Buri province on the Tha Chin River. These urban areas are vulnerable to the damage caused by fluvial and pluvial floods because of their locations, current lifestyle and housing design, and climate extremes in recent years. In 2011, the Chao Phraya River Basin received severe damage, especially the lower central plain, costed economic loss of around 46 billion USD due to the estimated 77.6 km^3 of floodwaters covering 100,000 km^2 (Loc et al., 2020) from September 2011 until discharged in February 2012.

Ayutthaya City Island, the capital city of Siam from 1350 until 1767 A.D., is surrounded by the Chao Phraya, Lopburi, and Pa Sak Rivers. The City Island is also regarded as a world heritage city covering an area of approximately 2.89 km^2 and is also protected by UNESCO World Heritage Sites (WHS) (Phra Nakhon Si Ayutthaya Provincial Office, 2021). Strenuous efforts for countermeasures of flood protection after the 2011 megaflood include the building and non-building measures under the large-scale nature-based solutions (NBS) for flood mitigation. These measures involve flood protection systems, including dikes along the canals and polders, the drainage systems that involve canals, pump stations, regulators, and water gates, as well as water-retention areas, and the adjustment of crop cultivation calendar for the farmers in the water-retention fields (Ghozali et al., 2016; Prabnakorn et al., 2021; Hamers et al., 2023; Penny et al., 2023).

Physically, the water-retention area is the key to alleviating the immediate runoff during heavy rainfall in densely populated areas. The low-lying agricultural fields could capture floodwater and store water for agricultural use at the beginning of the dry season. The water-retention fields in the lower Chao Phraya Basin covered both the west and east sides of the Chao Phraya River, totalling 12 fields, with a total area of 1,840 km^2 in 12 provinces, capable of cutting off 1,500 million cubic meters of water (Mekphruksawong and Nakeesin, 2017). Implementing the large-scale NBS for flood mitigation projects in Chao Phraya lowlands that divert the fluvial and pluvial floods into the water-retention fields in Ayutthaya has been fully operated since 2019.

This research is the first attempt to explore the impacts of large-scale NBS projects on the livelihood of the farmers and vulnerable in the water-retention area to get feedback from local communities on their resiliency against climate changes at the farm and community level under the large-scale NBS flood management. The study aimed to understand the contexts of farmers and their adaptation to drive sustainable and environmentally positive food production and the roles of the rural in supporting the livelihood of urban areas by exploring a philosophical orientation rooted in Thai culture and society. Moreover, the UN-Habitat Guiding Principles for urban-rural co-development (United Nations Habitat, 2019; Kjaersgaard and Yang, 2022) were used to evaluate the agricultural communities under climate threats to their vulnerability and farmers' contribution to sustainable development. Lessons learned from local food systems in the flood-prone area in lower central Thailand impacted by the El Niño-Southern Oscillation (ENSO) drought in 2015/2016, along with 2017/2018 and 2021/2022 floods from La Niña events, could be used as feedback examples for practical transformation to reduce community vulnerability in other regions facing drought and flood.

2. Methodology

The central plain of Thailand is divided into the upper central plain, undulating terrain with an average height between 40 and 60 m above mean sea level, and the lower central plain, which has an elevation of around 0–20 m above sea level. The altitude in the north of the lower central plain gradually decreases to an average height of 2.5 m above sea level in Ayutthaya province. The lower central plain is a flat and important arable land covering an area of 19,000 km^2. Five densely populated provinces, namely Suphan Buri and Nakorn Pathom on the Tha Chin River and Pathum Thani, Nonthaburi and Bangkok on the Chao Phraya River surrounding the rural agricultural area of Ayutthaya are shown in Figure 1.

This study was conducted between May 2016 and November 2022 in Lat Bua Luang District, the rice-growing district southwest of Ayutthaya (Molle et al., 1998). This district is included in two water-retention fields under the NBS project fully commenced in 2019, i.e., Chao Chet field and Phraya Bunlue field, separated by the Phraya Bunlue irrigation canal as shown in Figure 2. This irrigation canal plays a significant role during the rainy season under the NBS projects as the diversion canal between the Chao Phraya River in Ayutthaya and Tha Chin River in Suphan Buri province. Chao Chet field on the north side of the canal helped retain the pluvial and fluvial floods received from northwest Ayutthaya; otherwise, the water overflowing into the Phraya Bunlue field on the south side of Ayutthaya, Nonthaburi, Pathum Thani, and Bangkok, as happened in 2011 megaflood.

Under the NBS projects, the Chao Chet field was designated to receive water from Chao Phraya River and Ayutthaya City Island after rice harvesting in late September each year. The NBS projects use the transverse irrigation canals and Noi River connecting the irrigation system in the lower west bank of the Chao Phraya River to the Tha Chin River to enhance the water drainage from the water-retention fields into the Gulf of Thailand.

Interviews and on-site data collection were conducted using participant observation through informal interviews. The

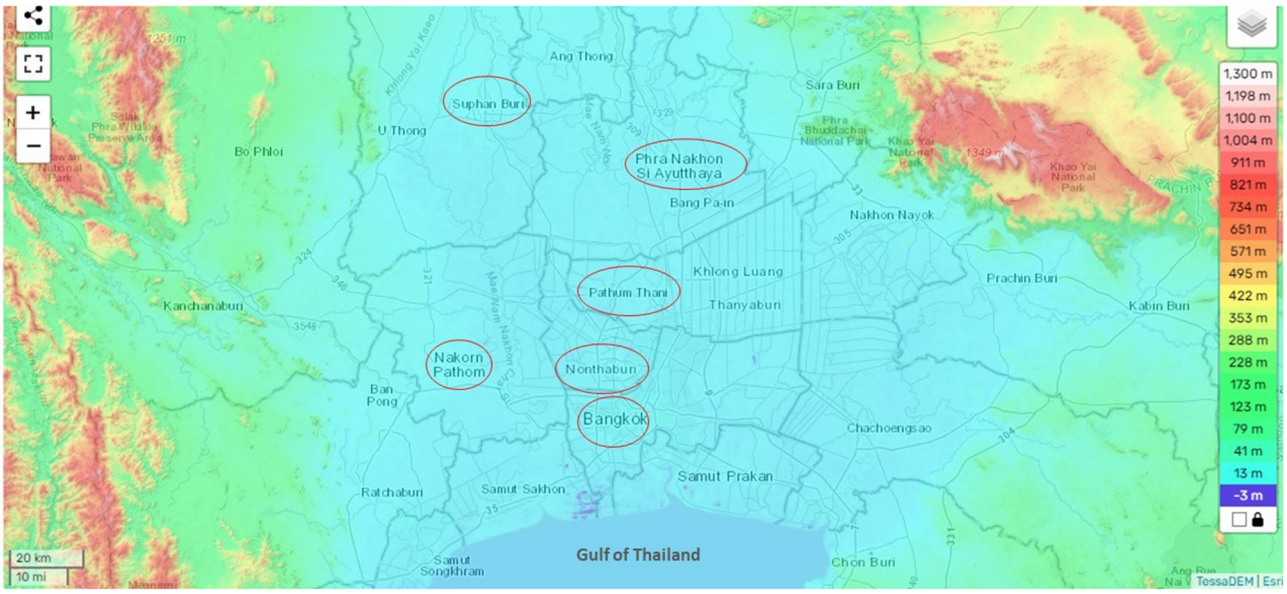

FIGURE 1
Topographic map of the lower Chao Phraya basin indicating provinces surrounding the rural agricultural area of Phra Nakhon Si Ayutthaya. Map was obtained from https://en-gb.topographic-map.com/map-qmhqtj/Phra-Nakhon-Si-Ayutthaya-Province/?center=14.28035%2C100.32852andbase=4andzoom=11.

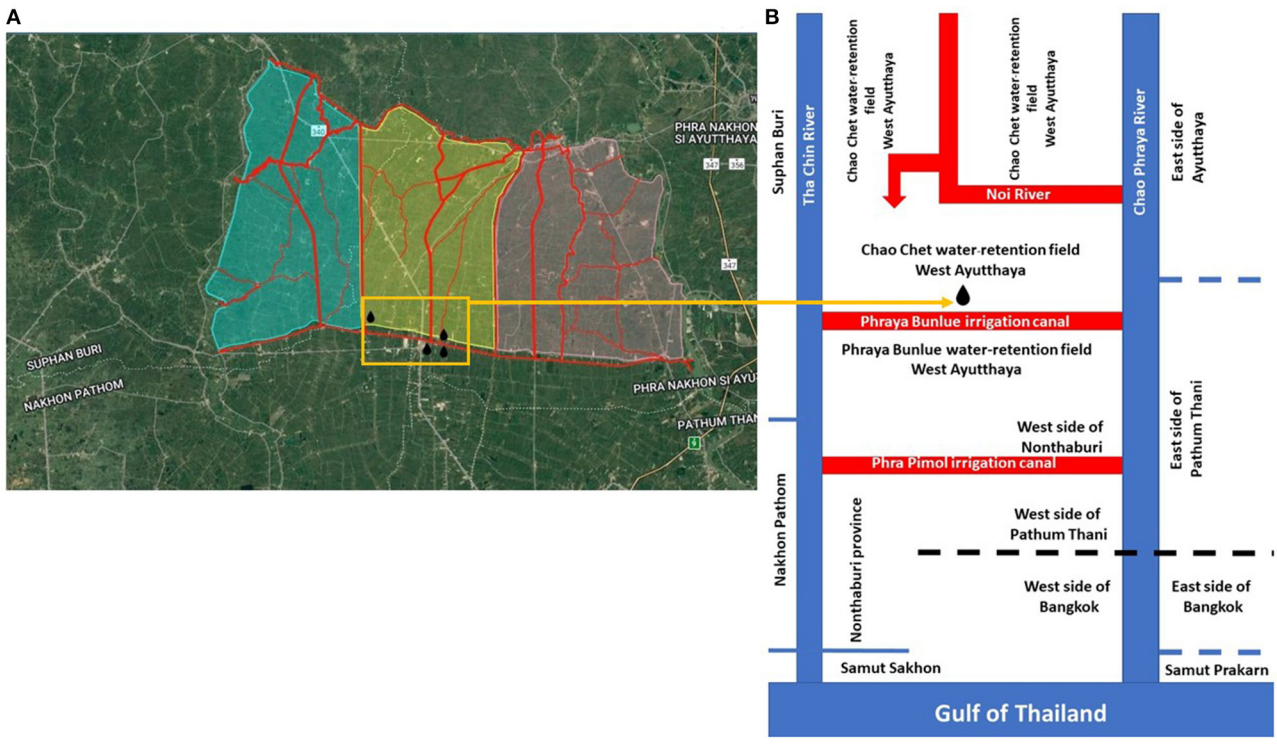

FIGURE 2
Water retention field on the west of Chao Phraya River: **(A)** Chao Chet water retention field and **(B)** Phraya Bunlue irrigation canal separating Chao Chet and Phraya Bunlue water-retention fields. The study area in 4 sub-districts was indicated as water droplets. The satellite map was obtained from https://www.google.com/maps/d/embed?mid=1bEGNodfblutexjx9Lfsh7quairl&ll=14.273392295696658%2C100.173653616259 81&z=11.

interviewees were from four sub-districts, i.e., Phraya Bunlue and Lakchai sub-districts in Chao Chet field and Singhanart and Klong Phraya Bunlue sub-districts in Phraya Bunlue field. They experienced the impacts of the ENSO and La Niña events during the study period of 6 years. Nineteen farmers were interviewed on the resilience issue of (a) lifestyle change during the past 6

years, (b) the changes in the productivity of agricultural products, modification of cultivation activities, and (c) their opinions on building a network of agricultural communities. Fourteen out of nineteen interviewees are domiciled in the study area and experienced at least four floods from 1975 to 2022 (4 decades). This criterion was to observe the farmers' viewpoints before and after the large-scale NBS flood relief projects.

The study also reviewed published data, such as national and provincial development plans, as the primary source. Peer-reviewed research articles in Thai and English in the public domain were used as secondary sources to assess the context of an agricultural area and policies on agricultural infrastructure development and water management in the lower western part of the Chao Phraya River Basin.

I applied the UNH guiding principles (GPs) regarding the issues of locally grounded interventions (GP1), integrated governance (GP2), functional and spatial systems-based approaches (GP3), financially inclusive (GP4), and environmentally sensitive issues (GP8) to examine the perception and resiliency of farmers in areas experiencing natural disasters before and after the implementation of NBS projects and report them as descriptive analysis, with emphasis on GP2, GP3, and GP4.

3. Results and discussion

3.1. Influence of the large-scale nature-based solutions (NBS) for flood mitigation in the lowland Chao Phraya River on the livelihood of the farmers

The highly coordinated NBS projects have helped manage water to alleviate fluvial and pluvial flooding in the lower Chao Phraya Basin. Most water-retention fields in Ayutthaya are private lands belonging to smallholder farmers or rental lands for rice farming–not state lands. The NBS projects effectively reduced the economic loss of urban areas and industrial estates of Ayutthaya, Nonthaburi, Pathum Thani, and Bangkok during the last 4 years. However, the high-water elevation and the duration of water logging until late November or December have made people in the water-retention fields in rural Ayutthaya and Suphan Buri suffer a very different way of life than before the implementation of the large-scale NBS projects in 2019. The water-logging period extended from 1 to 3 months, especially in the years affected by La Niña events consecutively.

In relieving flood victims during late 2021 and 2022 caused by severe La Niña events, the cabinet approved a budget to compensate disaster-affected areas during the rainy season nationwide. The duration of the disaster, criteria, and payment methods for flood-affected habitat, such as sudden floods, water overflowing the banks, and the result of water drainage that makes people unable to live, was declared. The Ministry of Interior was responsible for the subsidy only once a year after the village headmen inspected the houses, and local executives and community leaders endorsed the villagers' requests based on the number of flood days and damages. For registered farmers, the Ministry of Agriculture and Cooperatives provided monetary assistance for farmland damaged to the extent that it could not be restored to its original condition. The amount of compensation depends on the type of damaged farmland, fish farms, and livestock. The criteria for the duration of a disaster and financial assistance measures in 2021 differed from 2022. They were less than the actual damage repair cost (data from interviews with village headmen and community leaders between October and November 2022).

However, the long water-logging period of over 1 month could wear off the farmers' tolerance and resiliency in some sub-districts in Lat Bua Luang after consecutive years. The use of their farmlands as water-retention fields in 2021 and 2022 consecutively has already triggered their resentment. I also noted that the aid from the state still needs to include the plan and budget to help the farmers discharge the logged water from their fields into the central irrigation system after the rainy season has ended in October. The smallholder farmers in the Chao Chet water-retention field have been responsible for the fuel for water discharge cost to prepare their farmlands for rice cultivation in December; otherwise, they lost opportunities to grow off-season rice.

Four extracts below summarize the farmers' viewpoints and their resiliency for survival in drought and flooded areas from 2016 to 2022. It should also be noted that the COVID-19 pandemic caused periodic city lockdowns and travel restrictions during 2020 and 2021.

3.1.1. Farmer L (Phraya Bunlue sub-district, Chao-Chet water-retention field, 50s years old)

Farmer L is a community leader and contractor. His main income is from rice growing and construction. He and his family experienced waterlogging in 2021 and 2022 from the large-scale NBS projects. Farmer L grows rice on his land, and he also rents land which is also in the Chao-Chet water-retention field to grow rice. He experienced pluvial floods before and after the large-scale NBS projects and commented that he could manage to discharge the water from his rice fields to the Phraya Bunlue irrigation canal and grow three rice crops yearly. He preferred to grow rice and sell paddies to nearby rice mills than changing agricultural activities to grow other crops.

3.1.2. Farmer T (Lakchai sub-district, Chao-Chet water-retention field, 20s years old)

Farmer T is a Young Smart Farmer (YSF) programme member under the Ministry of Agriculture and Co-operatives. He and his family experienced waterlogging in 2021 and 2022 from the large-scale NBS projects. The family's main income was from a vegetable garden. He invested in a banana plantation on his farmland in 2020 after receiving a budget from the Ministry of Interior for landscape modification on sustainable agriculture. He commented that houses in Lakchai sub-district were flooded for almost one meter since November and his family lost bananas and income after investment and re-planting. The waterlogging lasted until early January, and he needed to prepare the farmland for the 2023 plantation. He suggested that the state should have compensated people affected by water diversion into the fields using different criteria from those who received compensation from a natural disaster.

After the water receded in January 2022, Farmer T worked on matching plant species of fruit trees and woody trees for his landscape-modified farm. He received technical assistance, suggestions and saplings from YSF mentors and government offices in the Lat Bua Luang district. He planned on networking with other farmers and formed a community enterprise.

3.1.3. Farmer S (Singhanart sub-district, Phraya Bunlue water-retention field, 60s years old)

Farmer S is a farmer who owns large farm types of equipment such as tractor, cultivator and trailer. His main income is from rice growing and wages from rice growing for hire. He and his family experienced waterlogging only in 2021 from pluvial floods and shallow groundwater levels. Farmer S grows rice on his land and rents land in the Phraya Bunlue water-retention field to grow rice. He experienced pluvial floods before and after the large-scale NBS projects and commented that he could manage to discharge the water from his rice fields to the Phraya Bunlue irrigation canal and grow three rice crops yearly. He prefers selling paddies to nearby rice mills than changing agricultural activities to grow other crops. However, he and his family are interested in organic farming but have yet to decide on a budget and market.

3.1.4. Farmer P (Klong Phraya Bunleu sub-district, Phraya Bunlue water-retention field, 60s years old)

Farmer P is a community leader and retired schoolteacher. His main income is from his pension and farmland. He and his family experienced waterlogging only in 2021 from pluvial floods. Farmer P grows multiple crops including rice and receives a budget from the Ministry of Interior for landscape modification on sustainable agriculture. He is a mentor in the YSF programme member of the Ministry of Agriculture and Co-operatives and sustainable agriculture practices for the Lat Bua Luang district.

Considering the UNH urban-rural linkage guiding principles on locally grounded approaches (GP1) and integrated governance (GP2), adequate financial and social assistance should be integrated into the master plan for flood drainage from the water-retention fields, mostly private lands in the Ayutthaya case. For the site-specific recommendations in this study, I propose that the provincial office have a consistent action plan(s) and budget for a floodwater-discharge program to help relieve farmers in water-retention areas sooner than December to reduce farmers' opportunity loss. Otherwise, slow violence could occur due to the repeating urban-rural disparities every year.

3.2. Sufficiency economy (SE) philosophy and sustainable agriculture concepts in Thailand

The "Green Revolution" after World War II aimed to produce enough food to meet the needs of the world's population by increasing crop yields and agricultural production through expanding arable land, improving crop traits to obtain productive varieties, and the use of all forms of chemicals or aids to enhance production yields. In the 1960s, the Rockefeller Foundation and Ford Foundation encouraged the establishment of the International Rice Research Institute (IRRI) in the Philippines to breed rice varieties having short and straight leave, respond to high fertilizers, are not easy to topple and are not sensitive to the light range while producing high production yield. The consequence of the monocropping practice of these semi-dwarf rice varieties was an outbreak of insect pests, for example, the brown planthopper (*Nilaparvata lugens* Stal) outbreak attacking Thai rice that has the same characteristics as the IRRI rice cultivars during the 1970s, and the incidents in Bangladesh that started in the same decade (Zahirul et al., 2009).

The Agricultural Land Reform legislation was also enacted in 1975 to improve the rights and ownership of farmland and habitat for smallholder farmers. Under this act, the Ministry of Agriculture and Cooperatives can take the state land and purchase or expropriate the lands from landowners who do not use the land by themselves or have excess land and offer the lands to farmers who do not possess farmlands or habitats (LIRT, 1976).

Despite the positive effect of the mainstream economic and social development plans focusing on productivity and gross domestic product, which increased the economic growth rate, these positive effects only sometimes spread to rural communities. As a result, the rural people weakened since they relied on the market and intermediaries for capital goods. The degradation of natural resources and land grabbing became apparent. The traditional kinship and inclusion system for managing previously existing resources was reduced. The knowledge landscape used to solve problems was forgotten and disappeared over the years (ORDPB, 1999).

The late King Rama IX noted these changes as his majesty mentioned in 1974 that the development should be carried out in a series by establishing the sufficiency concept in the people to create primary stability at the household level, i.e., the first step of the sufficiency economy (SE) philosophy. When economic stability at the household level is established, gradual building to enhance the prosperity of the collectives can be done, followed by the next higher level of economic status (ORDPB, 1999).

The principle of reducing dependency, increasing the ability to control production by oneself, and reducing the risk of being unable to control the market system was suggested in 1974. This SE philosophy differs from mainstream economic development, as detailed by Avery and Bergsteiner (2016). Mainstream economic development focuses on productivity, while SE transformation focuses on production and consumption within the scope of income limitations or available resources. The SE philosophy under the Royal Initiative is based on the foundation of Thai culture and covers three elements:

- Moderation: sufficiency at a level of not doing something too little or too much at the expense of oneself or others;
- Reasonableness: evaluating the reasons for any action, understanding the full consequences of the action, applying accumulated knowledge and experience along with analytical capability, and having self-awareness and foresight; and

- Self-immunity: the ability to withstand shocks, adjust to external changes, and cope with unpredictable or uncontrollable events.

These elements must be carried out based on knowledge and prudence in the relevant fields and with moralities regarding honesty, patience, perseverance, and intelligence.

The direction of the national economic and social development policies between 1974 and 1997 only included this SE philosophy in the national policy in the 1997 major economic crisis after the Thai currency devaluation. The SE philosophy has been included in the Ninth National Economic and Social Development Plan (2002-2006) (NESDB, 2001) and continues the actions in the following national plans and the current long-term National Strategy framework for 20 years (2018–2037) (NESDB, 2018).

The second step of SE philosophy, suggested by the late King Rama IX in 1997, focuses on the new agricultural theory (NAT) since Thailand faced an economic crisis that year. NAT focuses on landscape design for sustainable agriculture (as shown in Figure 3) and the initiation of farmer collective formation. NAT landscape design uses 30% of the land to store water for agricultural purposes, collect rainwater during the rainy season, and use it for planting in the dry season or raising animals and aquaculture. The second 30% of the area grows rice in the rainy season, so the family has enough carbohydrate sources throughout the year, and the surplus can be sold to reduce food costs and be self-reliant. The third 30% is for growing fruit trees, perennials, vegetables, field crops, and medicinal plants for daily usage or merchandising. The last 10% of the land is for habitat, raising animals, roads, and buildings.

The third step of the SE philosophy can then be implemented when the farmers have an agricultural surplus and work collectively. The late King Rama IX suggested promoting cooperation among farmer collectives and funding sources, i.e., banks and private sectors. Farmer collectives usually have more bargaining power than individuals.

The awareness at grassroots levels and implementation of the SE philosophy have been revisited and re-intertwined with Thai culture and integrated as policy tools for over 25 years. Thais have learned to adapt after the economic crisis in 1997 and be more resilient during the Russian crisis (1998), the Great Recession from US subprime mortgages (2007–2009), the European crisis (the 2010s), the 2011 megaflood-induced economic crisis, the economic loss under the rice-pledging policy between 2011 and 2013, and the COVID-19 crisis (2020–present). Thailand has remarkably reduced poverty in the past three decades (World Bank Group, 2022). The national poverty rate fell from 58% in 1990 to 6.8% in 2020. However, the progress in poverty reduction has decelerated due to the slowing economy, declining farm and business incomes, and the COVID-19 pandemic.

Thailand still needs strong and sustainable social and economic development in urban and rural areas to escape the middle-income trap and be more adaptive against increasing climatic variability and extremes threatening humanity and ecological systems. Agriculture plays a crucial role in Thailand's economy. Although the agricultural sector accounts for 8% of Thailand's GDP, it employs around one-third of its labor force (World Bank Group, 2022). The long-term Thailand Strategy Framework (2018–2037) (NESDB, 2018) and the Sustainable Development Goals (SDGs) determine the policy priorities and corresponding strategies during the past 4 years since implementation in 2018, focusing on improving access and management of water resources, promoting mitigation and adaptation to climate risk and climate change, improving access and use of technology among smallholders, and promoting land consolidation and efficient use of farmland (World Bank Group, 2022).

The COVID-19 pandemic has exposed social inequalities and vulnerabilities of food systems in each country, including Thailand, despite being one of the world's major food exporters. The OECD (2020) reports that the COVID-19 pandemic has affected agricultural production and income due to restrictions on cross-border movements and government lockdown policies in each country. The delays and disruptions to transportation and logistics services, border closures, and further procedures have created congestion and delays and decreased food availability and accessibility due to disruptions in domestic and global food supply systems (Tansuchat et al., 2022). Such cross-border mobility limitation affected the transportation of perishable products and caused a massive reduction in Thailand's chilled food exports.

On the upstream side of the food value chain, farmers are affected by the limitation of cash flow, higher cost of capital goods such as fuel, agrochemicals, etc., and the migration of family members back to their hometown due to job loss in industrial and service sectors. Nonetheless, the household had enough food for their members during the provincial lockdown from their farms and short-distance trading among farmer collectives (data from interviews with village headmen and farmers between October and November 2022).

3.3. Food as a medium to connect rural and urban population: evaluation by the UN-Habitat guiding principles

The increasing frequency and severity of extreme weather events, such as floods or droughts, has caused an estimated 193 million people in 53 countries or territories to experience acute food insecurity in 2021 (FAO, 2022). Climate and variability will increase global malnutrition, childhood deaths, food risk factors, and food-related non-communicable diseases (NCDs) by 2050. In addition, the political and economic crises and the COVID-19 pandemic further increase these impacts (FAO, 2022). The ongoing global challenges demand greater climate resilience within the current food systems, from agricultural production to sustainable consumption, to ensure access to safe and nutritious food by boosting nature-positive production, advancing equitable livelihoods and value distribution, and building resilience to vulnerabilities under shocks and stresses (Von Braun et al., 2021) detailed in Figure 4.

This study used empirical qualitative research on a case study in the area under constraints from climate extremes and the global pandemic since COVID-19 has severely impacted the global food supply chain. People in flood-prone areas: rural agri-food producers, workforces in the food value chain, and food consumers in urban communities with different

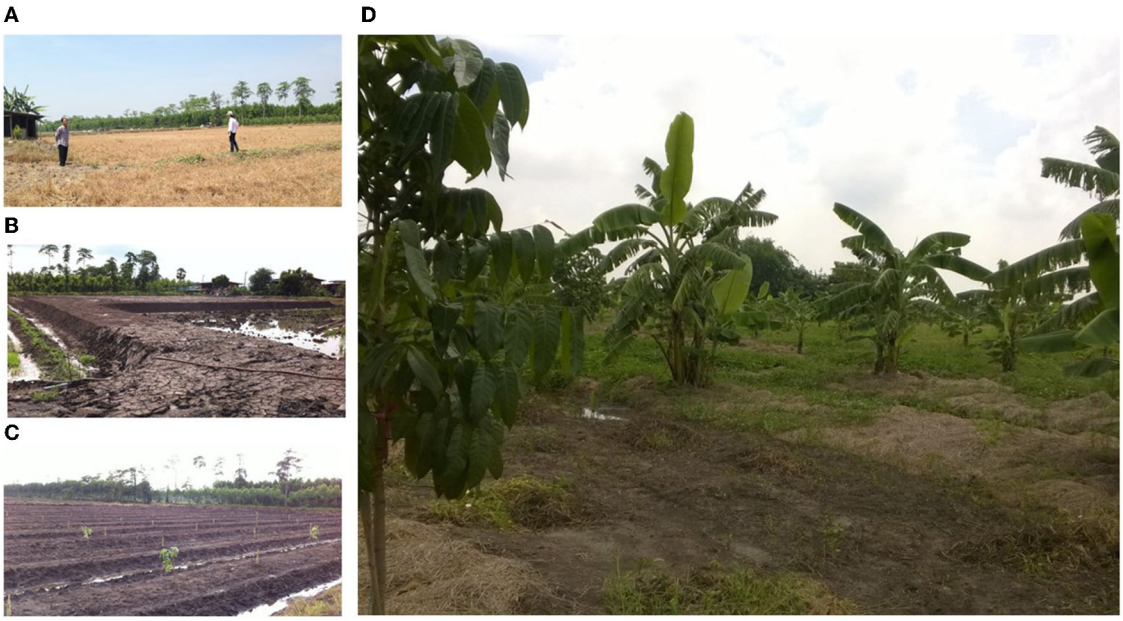

FIGURE 3
Changes in the farm landscape (coordinate: 14.1510441, 100.3984613) and productivity of agricultural products during 18 months of landscape modification to accommodate drought in May 2016 and flood in October 2017: **(A)** May 2016; **(B)** August 2016; **(C)** September 2016 and **(D)** October 2017. The farmers use the ridge and furrow system and large farm ponds to store water during the rainy season for use during the dry season according to the new agricultural theory (NAT).

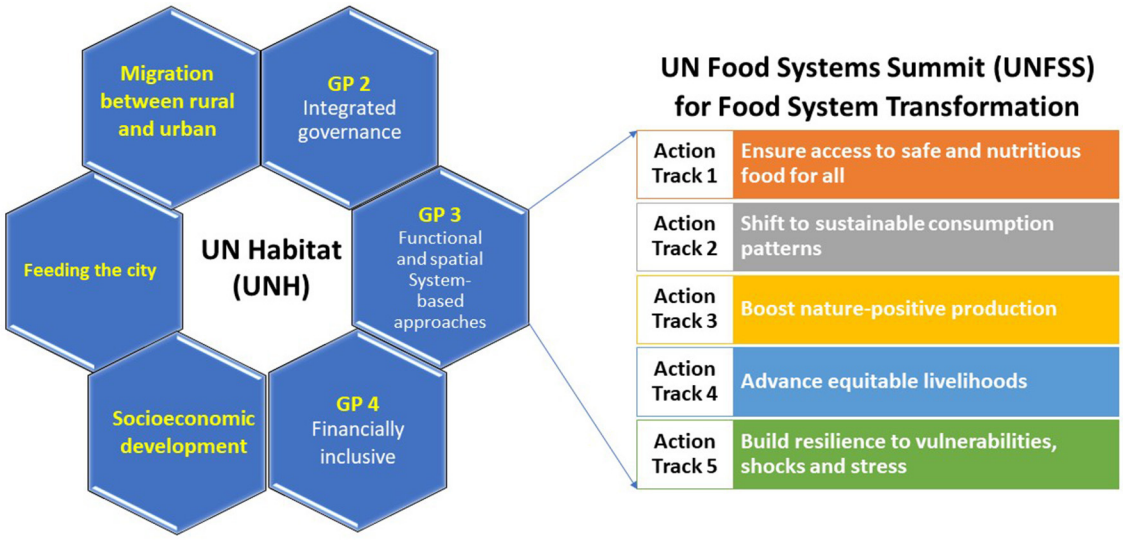

FIGURE 4
Relationship between UN Food Systems Summit Action Tracks and UN Habitat guiding principles to achieve sustainable development goals.

economic statuses were focused on. Under the 2021UN Food System Summit (UNFSS) Action Tracks fostering partnerships in global food systems (Von Braun et al., 2021) shown in Figure 4, there are some criteria on UNFSS overlapping with the UNH urban-rural linkage guiding principles that I shall address in regards to the promotion of urban-rural linkages, particularly the GP2 (integrated governance), GP3 functional and spatial systems-based approach) and GP4 (financially inclusive) (United Nations Habitat, 2019) to help enhance resilience to vulnerabilities, shocks, and stress, particularly for people in the cities who have faced food shortages and unaffordability.

3.3.1. GP 2 integrated governance

In strengthening the governance mechanisms by integrating urban-rural linkages into multi-sectoral, multi-level, and multi-stakeholder, Thailand has operated under the framework of the

National Strategy (2018–2037) to integrate the public and private sectors, civil societies, research and professional institutions, and consumer associations through the coordination mechanisms led by the Ministry of Agriculture and Cooperatives and the Ministry of Public Health (Office of National Food Committee Secretariat, 2018). This is to promote the production of safe agricultural and food products to ensure the availability of food sources that meet the Food and Drug Administration's (Thai FDA) safety criteria and comply with the Codex Alimentarius international standards. A recent campaign requiring government-private partnerships is reducing health risks of non-communicable chronic diseases, for example, the imposition of a sugar tax on food and beverages and a tax on salt in instant noodles, sauces, and snacks. The food industries need to reduce the amount of sugar and salt in their products, driven by the progressive tax rate. This is to lower the sugar and salt intake proportion to minimize consumers' risks of obesity, diabetes, and high blood pressure.

3.3.2. GP 3 functional and spatial system-based approaches

In Thailand, local or community food systems are essential in delivering sufficient, safe, nutritious food for consumers. However, most farmers remain vulnerable to the effects of climate change, which causes reduced production yields and food loss, and increases food prices in rural and urban areas. Global climate change has increased global surface temperature, with more warming every decade than the previous decade (IPCC, 2014). It is one of the causes of food insecurity due to less agricultural productivity.

Farmlands occupy 73% of the Ayutthaya land area and are mostly owned by smallholder farmers. The farmers can access water for agricultural practices through irrigation canal systems constructed and expanded since King Rama V reign over a 100 years ago. However, farmers in Ayutthaya mainly grow rice. Paddy fields comprise almost 90% of farmlands (Phra Nakhon Si Ayutthaya Provincial Office, 2021). Enhancing the collective efforts of farmers who joined the clustered farming projects helped improve agricultural practices and market negotiation with food exporters and hypermarket Head Quarters in Bangkok. The Department of Agricultural Extension conducts farmer training regularly to increase the number of farmers/clustered farms receiving Good Agricultural Practice (GAP) and Organic Thailand certifications.

The interviews and field observations between 2016 and 2022 suggested that the agricultural communities in some sub-districts were resilient in converting their farming practices to sustainable agriculture under drought and floods. The coordinating between stakeholders in the local food system, such as farmers, community leaders, farmers leaders, and farmer philosophers within the community at the sub-district level, along with the government officials and local government offices in the promotion of agriculture and community development, is essential for the adaptation as a collective.

Urban farming, on the other hand, faces more challenges than farmers in Ayutthaya rural since the land price in peri-urban Bangkok, Nonthaburi and Pathum Thani is more expensive. However, the City Farm Program launched in October 2010, funded by the Food and Nutrition Program of the National Health Promotion Foundation under the Prime Minister's Office, is a good example of public efforts on food security using low input in an urban context. Since then, non-profit organizations, private foundations, and social enterprises have supported urban farming projects by campaigning to use city-state lands for urban farming and organizing training courses and alternative food markets to support urban communities.

HRH Princess Maha Chakri Sirindhorn of Thailand initiated the school lunch program in 1980 by introducing a small-scale integrated farm to schools. Schoolchildren are encouraged to participate in food production, from growing fruits and vegetables to water management and using biological controls to eliminate pests. The excess food produced from school farms can be sold through school cooperative shops, and the surplus can be sold to local communities. The Princess has also promoted good nutrition programs for children, such as interventions designed to control iodine and other micronutrient deficiencies, promoting adequate child nutrition during Ramadan, and improving nutrition for secondary school students. This has reduced the number of iodine and iron deficiencies in Thai children. The children also learn how to account for and understand the principles of cooperatives.

However, the distribution of agri-food products between Bangkok metropolitan, nearby cities, and rural/agricultural areas further than a 100 km radius in the lower Cha Phraya basin is operated by large-scale logistic businesses and multinational corporates, especially during COVID-19 provincial lockdown. The supply chain through these businesses has advantages over small- and medium-scale food industries since they have distribution centers in many provinces. Thus, supporting local farms and non-farm enterprises and taking advantage of local food production and shorter food supply chains may help promote food and nutrition security in the communities. Integration across spatial dimensions in flood-affected food delivery inter-city is still within the responsibility of government support, social enterprises, and non-profit organizations.

3.3.3. GP 4 financially inclusive

Under the SDGs, the investors, shareholders, employees, customers, suppliers, and agricultural communities are involved in the food value chain as stakeholders (Sandberg et al., 2022). Food corporates can consider three primary responsibilities, namely the environment (Environment), society (Social), and corporate governance (Governance), known as the ESG model when considering investments. This ESG model helps build credibility by reflecting business roles and responsibilities toward stakeholders and business development for sustainable growth. Sustainable investments are gaining more influence in the capital markets (Sandberg et al., 2022). The ESG model, although not mandatory in Thailand, will impact the brand image and investment incentives. I proposed food industry in Thailand pay attention to ESG factors (non-financial reports to the authorities) on sustainable finance and investment.

The financial incentives for farmers and small- and medium-scale food manufacturers are supported by the government banks,

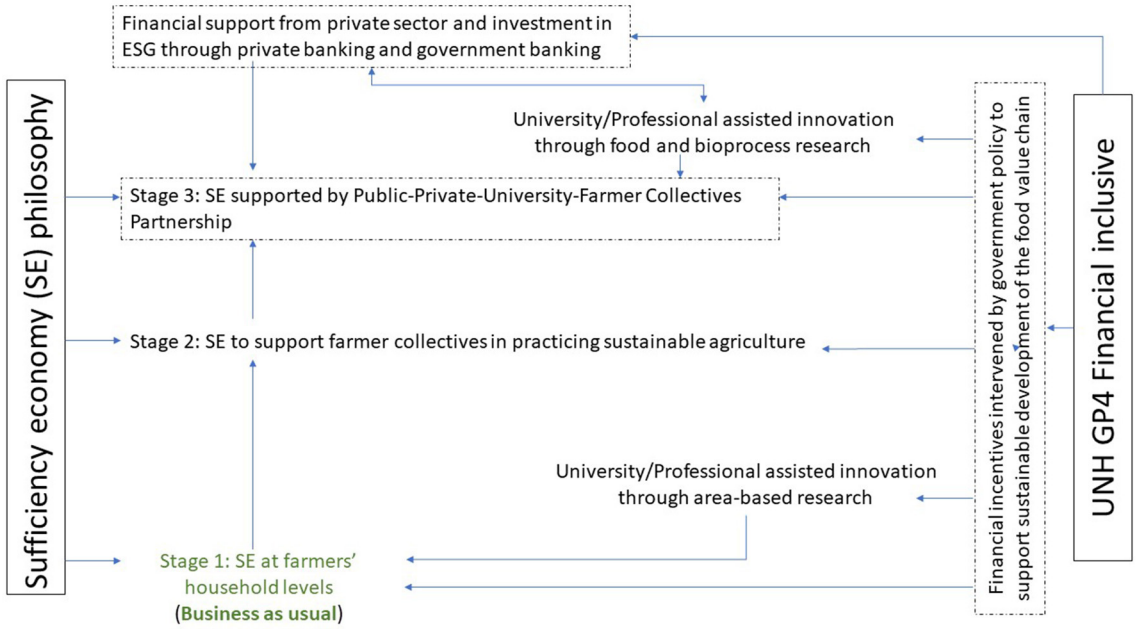

FIGURE 5
Overall concept of the inclusion of innovation and technology translation and coordination among key actors along the supply chain to support the transition of the local food system toward greater sustainability.

namely the Bank for Agriculture and Agricultural Cooperatives (BAAC), Government Savings Bank (GSB), and the Small and Medium Enterprise Development Bank of Thailand (SME bank) since they have specific mandates. Some banks offer packages that balance and strengthen urban-rural linkages for integrated rural and urban economic, social, and environmental development. For example, the BAAC has pledged new green credit to support organic farming and the plantation of woody trees of particular species listed by the Department of Forestry, Ministry of Natural Resources and Environment. The bank will raise funds by issuing green bonds for subscription by businesses that adopt ESG standards or individuals in the agricultural sectors to invest in planting the mentioned woody trees. The credit can be used as working capital for farmers to grow woody trees, develop organic farming, food safety projects, alternative energy, and environment and natural resource conservation.

Moreover, the government also funded the farmers on landscape improvement based on NAT farming and activities encouraging the third step of SE philosophy as agroecology aid. The Department of Community Development, the Ministry of the Interior and the social enterprise supported the implementation of landscape modification and training of SE philosophy and NAT farming during the fiscal year 2020–2022 to restore the economy and society affected by COVID-19.

The transformation of food systems through agroecology not only supports sustainable and healthy diets for all people and ends hunger and malnourishment in all forms (SDG 2) but also prevents health burdens (SDG 3), fostering economic growth (SDG 8), eliminating poverty (SDG 1), being responsible consumption and production (SDG 12), minimizing greenhouse gas emissions (SDG 13) and restoring land and conserving biodiversity (SDG 15). Integrating the UN Habitat GPs to drive analysis in this study along with UNFSS Action Tracks further illustrates the connection between the rural and urban areas to develop sustainable cities and communities (SDG 11) globally.

3.4. Next steps and critical areas to develop

The present policy framework and food and nutrition security implementation mainly include socioeconomic impacts but little emphasis on ecological outcomes. The versatility of climate-adaptive landscape design in a rural area enhances the economic production of agri-food products. Although the flow and distribution of environmentally positive agricultural commodities are currently promoted via public-private-university partnerships through research and innovation funding, foundations and social enterprises, and strong community and agricultural enterprises following the third step of SE philosophy, the long-term involvement of the private sectors, especially the large-scale companies and multinational corporates, should be encouraged through the financial inclusion and incentives (Figure 5) such as green bonds under ESG standards.

Most universities and research institutes work closely with the food industry on food and nutrition research, innovation, and technology transfer. However, they can increase their roles in area-based and community-based research to enhance the capacities of farmers or clustered farms. The universities can offer training or workshop for freshness preservation technology of agricultural commodities, effective cold-chain and packaging technology, on-farm food processing (mostly drying and fermentation or pre-processed for larger-scale food manufacturing), new food product development for characteristic

products in each sub-district (agri-based food and non-food), food safety and traceability, and food product legislation under the Thai FDA regulations.

This study focuses on rural communities' human strength and resilience in contributing solutions for urban and industrial areas in Ayutthaya, Nonthaburi, Pathum Thani, and Bangkok to alleviate annual flooding in the lower Chao Phraya River Basin over the past decade. Their resilience to survival is based on their acceptance and adoption of the sufficiency economy (SE) philosophy for more than 20 years. This SE philosophy is a social process included in Thailand's national policy and is currently in the National Strategy (2018–2037). However, it should be noted that there is always an urban-rural gap due to different development rates in the rural and urban communities and the characteristic dynamics of climate-resilient and adaptability in different regions of Thailand and other countries. Quantitative research on urban-rural cooperation is needed to identify the missing gaps, especially when there are distinctions in cultural norms, to build socially responsive and practical, effective, and balanced urban-rural co-development programs.

4. Summary

In the present study, I outlined how the SE philosophy, the innovative social processes, evolved and have imprinted grassroots and national policy during the past 25 years on the climate adaptation process of Thai farmers. Such social processes are critical to inducing food access equity and effectiveness of food distribution and should be incorporated into the nature-based solution on flood mitigation policy. Drawing from this case study, I showed how the large-scale NBS projects that include the local community's needs and are implemented through inclusive governance likely led to improved social, economic, and ecological outcomes. However, resilience to climate-induced floods is not evident in resource-constrained urban communities, including food availability, access to food, and affordability, which is the wake-up call in the urban areas during the COVID-19 pandemic. Therefore, to support urban communities to be more resilient to climate change, it is necessary to develop the urban people's abilities to live under the climate dynamics in addition to the focus on city infrastructure development. The adoption of the SE philosophy "at the national level" during the past 25 years has fostered partnerships in national food systems transformation to some extent. Local tradition and values, the SE philosophy for Thailand's case, can further global policy objectives for urban-rural co-development, as analyzed through the UN-Habitat Guiding Principles for urban-rural co-development.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

Conceptualization, fieldwork, and writing: PH.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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