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Community-Based Resilience Analysis (CoBRA) to Hazard Disruption: Case Study of a Peri-Urban Agricultural Community in Thailand

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Abstract: The expansion of cities and land use changes have led to the emergence of peri-urban areas representing a transition between fully urbanized and agricultural regions in Southeast Asia. Peri-urban communities provide essential ecosystem services but are vulnerable to climate-related disruptions and socioeconomic challenges. Utilizing their unique characteristics, peri-urban communities can contribute to sustainable development and resilience. This study assesses the potential of peri-urban areas to meet future challenges for sustainable development in a changing world, focusing on the local pandan farming community of Pathum Thani, approximately 53 km north of Bangkok, using the Community-Based Resilience Analysis (CoBRA) approach. A formally established group of peri-urban farming households identified COVID-19, water quality, and solid waste as their primary disruptive challenges. The community identified economic stability and resources (land ownership, financial security, and government support), community and social support (collaborative community, and healthcare facilities), an environmental dimension (sufficient food and clean water), and an information dimension (news and knowledge update) as key community resilience characteristics, which highlight their comprehensive approach to hazard resilience. The study concludes that the community was moderately resilient to hazards and COVID-19 was the primary disrupting event over the past 10 years. To address future challenges in peri-urban agriculture, it is suggested to focus on enhancing economic diversification, strengthening social networks and support systems, implementing sustainable land management practices, and promoting access to timely and accurate information. Additionally, investing in infrastructure for water management and waste recycling, supporting small-scale farming initiatives, and fostering collaboration between farmers and local authorities can contribute to building resilience in peri-urban agricultural communities.

Keywords: community-based resilience assessment (CoBRA); community resilience; pandan farmer; peri-urban agriculture; climate change; COVID-19

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1. Introduction

In an era characterized by unprecedented global challenges, the resilience of peri-urban agricultural communities has emerged as a critical area of study [1–3]. Peri-urban areas, representing the interface between urban and rural landscapes, are witnessing escalating pressures due to climate change and pandemics. As these communities navigate through a myriad of hazards, understanding their resilience becomes imperative. Gaps in risk awareness and hazard perception may erode the resilience of peri-urban communities [4]. Our research delves into the intricate fabric of peri-urban agricultural communities using a case study approach that specifically examines a peri-urban pandan farming community in Pathum Thani, Thailand. Through the lens of CoBRA (Community-Based Resilience Analysis), we explore how this peri-urban agricultural community navigates the challenges posed by climate change and COVID-19, with a focus on sustainably managing their environment (physical, social, and economic). More specifically, our research objectives aim to identify and assess key disruptions in the peri-urban agricultural (pandan) community, define resilience characteristics, and propose strategies for enhancing household resilience within the community. Our findings from the case study can be generalized, in some ways, as recommendations for sustainable management and enhanced resilience in other peri-urban agricultural communities.

Although peri-urban development can be viewed as a global phenomenon, there is no consensus on a universal definition of what constitutes "peri-urban", since characteristics may vary between the global north and global south countries, as well as due to specific land use patterns, socioeconomic drivers, and political systems [5,6]. Sahana et al. [6] have argued that an understanding of peri-urban dynamics is important to establish effective policies in governing the transformation of these areas. In general, a peri-urban area can be viewed as a dynamic transition zone between urban and rural land uses, having blended characteristics of each, to varying degrees, depending upon the typology used for the land use classification [7,8] and we pragmatically adopt this simple definition in our study. The spatial definition of peri-urban perhaps is more straightforward in our case as the study area is located within Pathum Thani province, one of five provinces making up the Bangkok Metropolitan Region (BMR) that surrounds Bangkok City (or Bangkok Metropolitan Administration, BMA), but are politically distinct from BMA.

Our study specifically refers to peri-urban agricultural communities, where we are defining such communities through their cultivation of plants and the raising of animals for food and other purposes in areas adjacent to cities and towns. This includes agricultural activities conducted in the transition zones between urban and rural areas. Peri-urban agriculture plays a crucial role in supplying fresh produce, livestock products, and other agricultural goods to urban populations while also contributing to employment, income generation, and enhancing food security and nutrition in urban areas [9].

Peri-urban farm communities face uncertain challenges and complexity. These areas often experience rapid urbanization, leading to the consumption of agricultural land, increased food demand, unemployment, and environmental degradation [10]. Farmers in peri-urban areas have to manage the challenges of limited government support, extensive urban sprawl, and changing socio-economic and land use conditions [9]. The multifunctional nature of peri-urban agriculture adds to this complexity, as different types of farmers (e.g., small-scale, commercial, organic) engage in diverse activities that shape the landscape and influence community dynamics in various ways [11]. Peri-urban farming contributes significantly to household food security, nutrition, income, and employment [12]. However, farmers also face constraints such as inadequate finance, weak market information systems, and the absence of laws regulating peri-urban agriculture [13]. The improvement in the political and institutional framework in some regions is encouraging [14,15], but collaboration among researchers, decision-makers, and the local community is necessary to ensure the sustainable development of peri-urban agriculture.

Overall, peri-urban agricultural communities must navigate a complex and uncertain landscape, which requires strategic planning, community engagement, and adaptation to mitigate risks and build resilience. There are a variety of definitions for resilience. In an early study [16] resilience was defined as the persistence of relationships within a system and its ability to absorb changes and still persist, although this definition has evolved more recently through various contexts and disciplinary lenses. The Intergovernmental Panel on Climate Change (IPCC) defines resilience as the ability of a system and its parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner. Resilience is recognized by the scientific community as comprising absorptive, adaptive, and transformative capacities. These capacities refer to the system's ability to withstand change while retaining function and structure, learn and adjust to external drivers, and create new systems when the initial state becomes untenable. Resilience emerges from the interactions between these capacities and the system's capability for self-organization [17].

2. Study Context

The study was conducted in the Tung Rangsit area which is a peri-urban region within Pathum Thani, a province in central Thailand, that is located on the lower Chao Phraya Delta (Figure 1). The Tung Rangsit Irrigation Canal System has a substantial historical background. The Rangsit Canal (Khlong) Project was established during the reign of King Rama V of Thailand in the late 19th century to open up new arable land that was previously wild, and generally inundated by water, transforming it into cultivated fields. The irrigation canal system aimed to enhance agricultural productivity and support rice cultivation in the region. The canal system was strategically designed to divert water from the Chao Phraya River and Pa Sak River and distribute it to the surrounding farmlands. The improved water management not only boosted agricultural yields but also contributed to the economic growth of the region [18]. This irrigation system played a crucial role in ensuring a reliable water supply for farmers, especially during the dry season. It has been a key factor in promoting agricultural development and contributing to the overall economic growth of the lower Chao Phraya Delta. However, after the opening-up period, rice paddy production in the Rangsit area suffered from severe drought. The canals from the project became shallow, and there also was a problem of production failure due to acidity in the soil surface. This drove away a great number of farmers from the area [19].

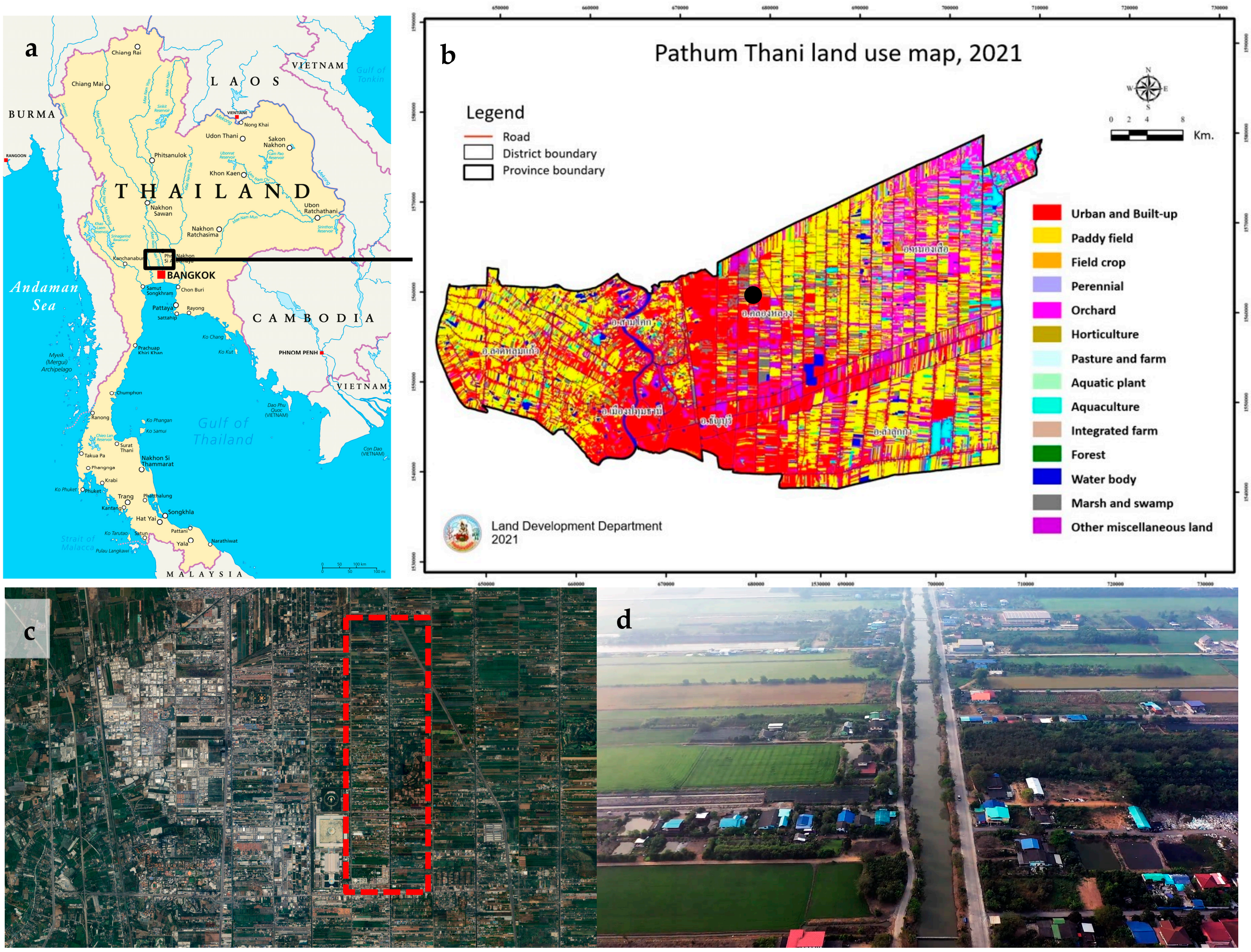

Figure 1. Study area: (**a**) location of study area in Thailand; (**b**) land use (2021) in Pathum Thani Province. The study area is marked as a black circle. The transition zone between urban (red color) and the mixture of agricultural land is clearly evident; (**c**) satellite view of the study area (specific area enclosed by the red box; and (**d**) a drone image of the study area, with Khlong 3.

In addition to its agricultural significance, Tung Rangsit has contributed to the development of residential and commercial areas in the region. The relatively even land surface provides a favorable environment for urban expansion and infrastructure development. So, Pathum Thani is facing rapid urbanization due to its proximity to Bangkok and its status as a key transportation hub in the region. The province has seen a significant increase in population in recent years, and as a result, urban areas are expanding rapidly. In particular, industrial estates have become part of the Pathum Thani fabric, promoted by affordable real estate rates and access to deep water ports, airports, and highways accommodating the movement of goods to both large local (Bangkok) and international markets [20–23]. Gated community development has become a more recent trend [24,25].

This growth has led to several challenges, including increased traffic congestion, air pollution, and pressure on infrastructure and services such as water and sanitation. Additionally, the conversion of agricultural land to urban areas has put pressure on local farmers and threatens the province's traditional agricultural practices [26]. While urbanization has brought economic growth and new opportunities, it also has created social and environmental issues that need to be addressed [23,27,28].

The low-lying nature of the Chao Phraya Delta makes the study area prone to seasonal flooding, especially during the monsoon season (e.g., [28]). Irrigated and rain-fed lowlands rice farming is highly susceptible to flooding, which often leads to submergence and significant damage. The 2011 flood in Thailand was the most severe and devastating flood in the country's history [29]. This event resulted from the interplay of multiple factors, and understanding the causes involved a combination of meteorological, hydrological, climate change, and human-induced factors [15,30,31].

After the 2011 flood, some rice farmers in central Thailand switched to alternative crops as a means of risk reduction [32]. Pandan is one of the choices that the Department of Agricultural Extension recommends to farmers in this area. As a result, in 2023, Pathum Thani province had 136 households cultivating a total of 96 hectares of pandan [14]. Pandan farms are particularly concentrated in the Khlong 3 area of Pathum Thani.

The pandan farming community in peri-urban BMR is shaped by unique social, economic, and environmental conditions. Socially, it features a blend of traditional farming communities, new urban settlers, and industrial estates, as noted above. Economically, farmers face financial pressures due to urban expansion and market fluctuations, though proximity to Bangkok provides access to urban markets [33,34]. Environmentally, the community contends with reduced farmland due to urban sprawl, loss of seasonal water retention areas [26], water management issues, and pollution from nearby urban areas, all within a changing climate that impacts agricultural productivity and livelihoods [24,27].

The study was conducted in the Khlong 3 local pandan farming community of Pathum Thani, approximately 53 km north of downtown Bangkok. The study area includes 40 hectares of pandan cultivated by a formally established group of 37 peri-urban farming families. This formal arrangement with the families fell under two different programs. First, a pandan enterprise group united these families in developing high-quality pandan production that meets Good Agricultural Practices (GAP) standards and market demands. All farmers also were members of The Large Pandan Land Plot Program established and promoted by the Department of Agriculture, Thailand. This program is an agricultural extension policy designed to promote collaboration among farmers living in the same area and cultivating similar crops. The program also has been developed and applied to other crop types throughout Thailand [35]. By participating in this program, farmers work together to produce and sell their crops in a coordinated effort to enhance their productivity and create greater bargaining power.

3. Materials and Methods

The Community-Based Resilience Assessment Model is a framework used to evaluate the resilience of a community in the face of various disruptions. It provides a structured approach to assess the capacity of a community to withstand, adapt to, and recover from these adverse events or disruptions. In general, existing resilience models can be divided into two main groups. The first group comprises models that aim to encompass and explain resilience on a system-wide level, such as those by the UK Department for International Development (DFID), and Technical Assistance to Non-Governmental Organizations (TANGO). The second group consists of models that aim to define and evaluate the attributes of resilience within communities, such as the Food and Agriculture Organization of the United Nations (FAO), Oxfam, and Tulane University assessment models [36]. The Community-Based Risk Assessment (CoBRA) stands out from these models by virtue of its emphasis on an understanding of resilience that comes from the *community's* perspective. So, the relevant resilience issues are identified to be included in an assessment [31]. This framework provides a practical package that can be effectively implemented in various contexts [36]. Moreover, the CoBRA framework uses a subjective approach to defining resilience and an objective approach to evaluating and measuring resilience [36].

Our study offers significant contributions and novelty by providing a comprehensive resilience assessment framework specifically tailored for peri-urban agricultural communities. CoBRA applications generally have occurred with agricultural communities in Africa [37] and to our knowledge this would be the first application in Southeast Asia. Our CoBRA approach addresses the compound impacts of climate change and pandemics, filling a critical gap in existing research that often overlooks the unique challenges faced by these agricultural communities. The study's integration of empirical evidence and innovative methodologies not only enhances our understanding of resilience but also offers actionable insights for policymakers and practitioners, thereby linking resilience-building directly to Sustainable Development Goals (including SDG1, No Poverty; SDG2, Zero Hunger; SDG3, Good Health and Wellbeing; SDG6, Clean Water and Sanitation; SDG8, Decent Work and Economic Growth; SDG11, Sustainable Cities and Communities; and SDG13, Climate Action) and informing future strategies for holistic and sustainable community resilience.

The CoBRA Framework recognizes that communities have unique social, economic, and environmental contexts that affect their ability to cope with and adapt to disruptions, and it seeks to address these contextual factors in its risk assessment and management approach. The CoBRA framework consists of four phases, i.e., preparation, field data collection, data analysis and reporting, and implementation of CoBRA findings, along with seven sub-steps (Figure 2).

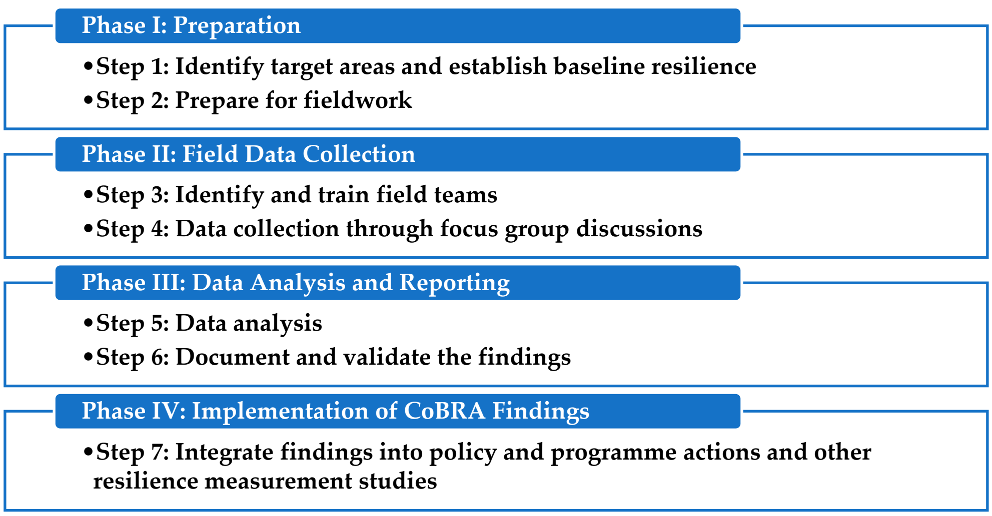

Figure 2. Phases and Steps in the UNDP CoBRA Assessment framework (adapt from [36,38]).

The research procedure was based on the CoBRA conceptual framework [15].

Step 1: Identify target areas and establish baseline resilience

This phase involved preparing for the assessment, including identifying the study area, defining the scope and objectives, and selecting appropriate assessment tools.

The study area was located in the peri-urban Pathum Thani province. The climate of the region based on the Koppen climate classification system is Tropical Savanna (Aw) with hot and humid summers, wet rainy periods, and warm winters. The mean annual temperature (30-year climate norms, 1982–2012) is 28.1 °C and the annual precipitation is 1050–1400 mm. Extensive pandan cultivation is located within the study area along with rice, banana, and aquaculture ponds. The participants involved in the workshops represented the group of 37 peri-urban farming families who joined based on their availability and willingness to join. The general characteristics of the peri-urban farming community were presented in the previous section, but we would note that the group initially was selected for study because the co-PIs were familiar with their activities via government outreach programs. The pandan farming group had a lead organizer from their community who was instrumental in the coordination of activities and dissemination of information.

Step 2: Prepare for fieldwork

Once implementing target communities were identified, the considerations involved determining the optimal timing and place for a CoBRA assessment and exploring opportunities for resource pooling. The actions included developing a comprehensive CoBRA Assessment Plan, creating a realistic budget estimate, and mobilizing internal and external resources to address any identified gaps. The output of this step was the finalized CoBRA Assessment Plan, staff, and other supporting tools and documents.

Step 3: Identify and train field teams

In this step, the considerations involved determining the composition of a CoBRA assessment field team. The workshop was planned by the co-PIs of the study team, two of whom are Thai and familiar with the Tung Rangsit social and physical landscape. Collectively, all the co-PIs had experience working with local communities (e.g., [27,39,40]). The co-PIs trained a team of six undergraduate (year 4) Thammasat Design School (TDS) Landscape Architecture students and graduate students (TDS, Design, Business, and Technology Management program) to facilitate the workshop so that there would be at least one facilitator dedicated to each participant team, as well as two additional facilitators and co-PIs to oversee proceedings (Figure 3). The field team training was essential for them to gain a full understanding of the CoBRA methodology so that they could most effectively facilitate the workshop with community members in real-time.

Figure 3. Community resiliency workshop (**a**) co-PIs and facilitators assisted participants in the discussion and then collected scores from each team; (**b**) workshop participants engaged in discussions while facilitators recorded their responses on flip charts.

After identifying the assessment field team, training was conducted for its members, incorporating both classroom and field-based instruction on data collection, following the step-by-step procedure outlined in the CoBRA Implementation Guidelines. The actions encompassed preparing for and finalizing the CoBRA sampling frame, completing the CoBRA assessment logistics plan, sensitizing sample communities, and developing a post-field team training report.

Step 4: Data collection through focus group discussions (FGDs)

During this phase, qualitative and quantitative data were gathered through Focus Group Discussions or community workshops. The data collected focused on understanding community perceptions, priorities, and existing resilience capacities.

During the participant registration time at the start of the workshop, facilitators encouraged participants to pin their pandan field locations on a map. Participants subsequently were arranged into teams of 4–5 members for a preliminary ice-breaking activity. The "Planting Resilience: Seeds for Climate Change Adaptation" is an activity aimed to encourage interaction, enhance communication, and introduce a concept of climate resilience. Subsequently, the facilitators explained and shared the understanding of resilience using easily understood graphics with locally relevant terms. Here, we use the Douxchamps et al. [17] definition of resilience: …the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation. Resilience refers to the ability to recover or bounce back from challenges, while exposure crises may involve situations where individuals or systems are significantly affected by external factors [41].

Once the ice-breaking activities and formal presentations were completed, each community team of 4–5 members was asked to provide a response to 6 key questions (Table 1).

Table 1. An overview of the CoBRA field assessment steps and the key questions addressed through the Focus Group Discussions (FGDs).

FGDs Step	Questions	Tools/Instructions
Step 1: Agree on the common description of resilience and exposure crises/disruptions	Q1: What are the crises or hazards affecting the community?	Establishing a shared understanding or definition of terms among relevant participants. The goal of this step is to ensure that all involved parties have a unified understanding of these terms before proceeding with further discussions or actions related to resilience and exposure to crises/disruptions. Each team member identifies several crises or disruptions they feel are important, listing them on paper cards.
Step 2: Main disruption	Q2: Which disruption has the most significant impact on communities, (each possibility is assessed and ranked, with the top 3 moving forward for further group discussion)?	Each member of each team was asked to: (1) allocate three beans (left-overs from the "Bean Game") to the card representing the most important disruption example; (2) assign two beans to the second most important disruption example; and (3) place one bean on the third most important disruption example. Facilitators collect scores from each team and record results on a flip chart. The top three disruptions facing their community were agreed upon through discussion and voting.

Table 1. *Cont.*

FGDs Step	Questions	Tools/Instructions
Step 3: Identify statements to define community resilience	Q3: What are the characteristics of a resilient community in the context of the (selected) disruption?	Based on the top disruption from the last step, each group is encouraged to think freely, and developed a no limit initial list of resilience outcome statements. The facilitators gather all statements and lists on the flip chart, summarizing which are the most common resilience characterization statements.
Step 4: Prioritize resilience statements/characteristics	Q4: What are the top three characteristics of communities or households that exhibit the highest resilience in effectively recovering from disruptions?	Based on the list of all outcome statements that describe resilience in community, participants are asked to identify the most important statements for their community. To facilitate an effective collection of responses, facilitators distribute six beans to each participant and instruct them to place the beans on top of the number. Specifically, participants are asked to: (1) allocate three beans to the number representing the most important statement; (2) assign two beans to the second most important statement; and (3) place one bean on the third most important statement.
Step 5: Rate the trend or change in achievement of resilience characteristics	Q5: Over the last five years, has your community's attainment of this characteristic gotten better, worse or stayed the same?	The workshop participants rated whether each resilience outcome statement identified in Step 4 has improved over the past 5 years and the overall extent to which the resiliency outcomes have been achieved. A scoring system (1 to 5) was used to quantify the changes for each resilience characteristic; 5 (Considerably better than before), 4 (Slightly better than before), 3 (Same as before), 2 (Slightly worse than before), and 1 (Considerably worse than before).
Step 6: Rate the community's progress in attaining the priority resilience statements	Q6: On a scale of 0 to 10, to what extent has this community achieved each of these characteristics in the current period, and in the last disruption period?	Each member is asked to score the community progress towards achieving their statements/characteristics of resilience on a scale of 0 to 10 (10 = totally achieved, 0 = completely absent). They scored each statement twice: first for the current/normal period and second for the last significant disruption period (agreed from step 2).

The data from the community workshop were photographed step by step. It is important to assign staff to record the result from each step from each team to recheck the result. Having multiple staff members involved in recording and checking the results enhances accuracy and reliability by providing an opportunity for cross-verification. This method ensures that the captured information is comprehensive, well-documented, and can be cross-referenced during subsequent analysis or reporting.

Step 5: Data analysis

Data entry was conducted both by facilitation groups during the field data collection period and collectively by the trained facilitators and co-PIs after the assessment, with a meticulous step-by-step recording of images. Employing a dual-source approach, comparing data from these two sources served as a mechanism for reviewing, detecting errors, and double-checking accuracy during the input stage, before progressing to the analysis.

While CoBRA primarily is a qualitative assessment tool, certain responses from FGDs could be organized and translated into numerical results based on scores and the frequency of mentions [16]. All data from FGDs were organized into an Excel spreadsheet format, and then summing and weighing scores for all statements were applied to identify key resilience characteristics and priorities within a community.

Step 6: Document and validate the findings.

Preliminary findings were shared and discussed with community members and stakeholders in validation workshops and by phone call follow-ups. The pandan community leader also assisted in disseminating results to all members of the farming group. Feedback from these sessions is incorporated into the final analysis.

Step 7: Integrate findings into policy and program actions and other resilience measurement studies.

Based on the assessment findings, action plans were developed in collaboration with the community and relevant stakeholders. These plans outlined strategies and interventions to strengthen the community's resilience based on identified priorities. An important consideration in this process was that once action plans were implemented, progress must be monitored over time. Continuous monitoring helped to assess the effectiveness of interventions and allowed for adjustments as needed.

As part of our project, a follow-up workshop was conducted focusing on organic farming practices and the development of pandan products. This workshop aimed to revisit the CoBRA findings and let the community further discuss potential improvements in health, the environment, finances, and community resiliency. It provided practical insights and further enhanced community resilience through sustainable development.

4. Results and Discussion

4.1. Study Participants and Their Understanding of Resilience

A total of 17 members from the farming collective community attended the first community workshop, with 12 being women and 5 being men. The mean age of the workshop participants was 57 years with a range of 37 to 66 years (Table 2).

Table 2. The peri-urban participants' profiles.

Contents			Frequency (No.)	%
1	Gender			
		Male	5	29.41
		Female	12	70.59
	Total		17	100.00
2	Age (Years)			
		<40	1	5.88
		40–50	2	1.76
		51–60	8	47.06
		>60	6	35.29
	Total		17	100.00
3	Years of experience in Pandan Farming			
		<5	1	5.88
		5–10	10	58.82
		11–20	4	23.53
		>20	2	11.76
	Total		17	100.00

The age structure of the Thai agricultural labor force from 1986 to 2016 indicates a decreasing percentage of individuals aged 15–59, from 95.67% in 1986 to 81.18% in 2016. Conversely, the proportion of workers aged 60 and over has been steadily increasing, rising from 4.33% in 1986 to 18.82% in 2016. This suggests a notable demographic shift in the Thai agricultural labor force over the past three decades, with an aging trend and a declining share of individuals in the 15–59 age range [42]. In fact, this aging (and feminization) trend for the agricultural sector is being witnessed throughout Southeast Asia [43].

Regarding climate change awareness, the study revealed varying levels of familiarity among farmers, with 70% reporting knowledge of climate change. This is similar to the findings from another study on farmers' perceptions of climate change [44], where the results of the household survey showed that 68–76% of respondents perceived changes in the environment and climate patterns. Those cognizant of climate change predominantly described it as alterations in seasonal weather patterns, highlighting unpredictability, drought, and flooding as discernible manifestations. Farmers delineated a spectrum of climate-induced hazards that could impact pandan cultivation, encompassing flooding, storm events, drought, excessive cold, and heat stress. Notwithstanding the variability in climate change awareness, a nuanced perspective emerged regarding its future implications. While 53% of respondents acknowledged potential climate change impacts on pandan farming, attributing lesser availability of water sources in the dry season, deteriorating water quality, and greater frequency of cold temperatures to global warming, a notable subset remained skeptical about impacts. Among the skeptics, flooding persisted as the predominant concern, compounded by issues such as pandan sprouting challenges during winter months.

The participant discussion after finishing the planting beans game revealed that resilience for them refers to their ability to withstand and recover from various challenges and adversities encountered in agricultural activities. This includes the capacity to adapt to changes in environmental conditions, such as fluctuations in weather patterns and natural disasters like floods or droughts. Additionally, resilience encompasses their ability to cope with socio-economic factors, such as market fluctuations, access to resources like land and water, and changes in government policies or support programs. It also involves their ability to maintain social networks and community cohesion, which are crucial for sharing knowledge, resources, and support during times of hardship.

4.2. Preliminary Identification of Disruptions

Participants were organized into four distinct groups to enhance the focus of discussions and activities, with group sizes consisting of 3, 4, 5, and 5 members, respectively. Facilitators gave each participant six beans to rank the most important disruption. Participants were instructed to place 3 beans on the most important disruption, 2 beans on the second most important, and 1 bean on the third most important. Each group identified and developed their own list of primary disruptions of concern that were included in a further evaluation by the entire group. The identified concerns encompass a range of issues, including natural disasters, pollution, public health, and economic factors, providing a comprehensive overview of the multifaceted environmental landscape. The preliminary list of disruptions identified by the individual groups is summarized in Table 3.

Table 3. Disruptions Identified by Workshop Groups.

	Group 1	Group 2	Group 3	Group 4	Total
COVID-19	2	12	3	5	22
Water pollution/Wastewater	2	8	5	6	21
Solid waste	3		6	7	16
Plant disease	2	4	5	3	14
Air pollution	3		2	4	9
Flood	3			5	8
Drought	1		4		5
Financial crisis			3		3
Dengue fever			2		2
Drug abuse	2				2

Water-related challenges, highlighting flood-related issues and drought, were prevalent across all groups. The analysis of these distinct but interconnected issues provides valuable insights into the varying nature of water-related challenges in the study area. The occurrence of both floods and drought suggests a need for adaptable and region-specific water management strategies to mitigate the impact of extreme weather conditions.

However, if we consider only climate-related hazards that farmers have experienced, the empirical investigation conducted within the pandan farming community revealed flood occurrences as the primary concern. The 2011 flood emerged as a pivotal event, cited by respondents as the most severe disruption experienced in their farming endeavors. Stem rot, attributed to fungal infestation during flood inundations, emerged as a significant consequence affecting pandan cultivation. Farmers expressed the formidable challenge of managing stem rot, highlighting its propensity to spread across crops and necessitating extensive clearing and replanting efforts. Financial burdens resulting from stem rot were notable, with one respondent disclosing an expenditure of 70,000 bath/rai and a subsequent two-year repayment period.

Further conversation in the group discussion illuminated the multifaceted impact of climate change on pandan farming. Flood-induced stem rot, exacerbated soil acidity, and stunted growth emerged as prominent consequences. Furthermore, farmers expressed apprehension regarding future climate change effects, anticipating adverse outcomes such as leaf burning during periods of excessive heat and stem rot in prolonged wet conditions. Notably, climatic extremes were perceived to impede pandan sprouting during excessively cold conditions.

In an outcome surprising to the study team, all groups identified pollution as a significant environmental issue, with a focus on water pollution and waste management. Wastewater emerges as a common concern across all four groups, highlighting the shared recognition of the importance of water management. The analysis revealed a unanimous concern about wastewater and water pollution, emphasizing the urgency of addressing this critical issue to ensure the availability of clean and safe water resources. While the farmers did not have specific water quality data on the khlongs for reference, they could visually understand the discharge plumes from local gated communities, industries, and commercial facilities (including wet markets), as well as the decline in the riparian zone's ecological quality. The presence of private solid waste processing properties within the Khlong area (Figure 4a), including leachate discharging to the local waterways, was well known to the farming community and emphasized the need for a comprehensive approach to mitigate environmental degradation. As a result of farmer's concerns, the study expanded its water quality sampling program (Figure 4b), the results of which are presented by Likitswat et al. (in preparation). Farmers also highlighted air pollution, particularly PM2.5 from open burning, as a significant environmental threat.

The unanimous identification of COVID-19 as a concern across all four groups reflects the global impact of the pandemic at the time of the workshops. However, the specific considerations each group associates with COVID-19 also touch on the intersection of health and environmental challenges. Furthermore, the inclusion of dengue fever as a concern in Group 3 adds a layer of complexity, highlighting the diverse public health issues faced by communities. Although Pathum Thani is a lower-risk province compared to many in Thailand for incidence of dengue fever [45], it remains a leading cause of hospitalization countrywide [46]. While some studies have reported a higher risk of dengue incidence in urban areas (e.g., [46]), others (e.g., [47,48]) have suggested dengue can no longer be considered an urban disease and that there is no distinction between urban and rural areas (see also [48]). A recent report from the Economist [49] on dengue management in Thailand concluded that "efforts to fight it are hindered by the absence of specific antiviral treatment, as well as limited prevention and vector control efforts", recommending the implementation of a national strategy to increase awareness of dengue risks, transmission, and prevention measures. These studies underscore the complexity of health concerns expressed by the peri-urban agricultural community.

Figure 4. (**a**) Solid waste processing facility in the study area; and (**b**) water quality sampling in upper Khlong 3.

Our research unveiled specific challenges within the peri-urban agricultural sector. Plant diseases and pest infestations were identified as substantial concerns, especially fungal diseases in plants and the presence of *Pomacea canaliculata* (golden apple snail) in agricultural fields. Additionally, one group highlighted financial issues within the context of the broader environmental challenges, emphasizing the economic strain faced by communities grappling with multiple crises.

4.3. The Disruption with the Greatest Impact

The set of main disruptions that initially were identified and discussed in the previous section subsequently were ranked by each group through a voting process and COVID-19 was identified as the top concern, followed by wastewater/water quality issues and solid waste.

It is likely that COVID-19 was identified as the top concern because it is the most immediately experienced disruption. This pandemic negatively affected the daily lives, agricultural working lives, and mental health of farmers throughout Thailand [50,51]. Our study found that COVID-19 had a detrimental impact on farmers' daily lives, increasing planting and agrochemical costs, decreasing agricultural product prices and extensions, and making agricultural markets and logistics more challenging. A significant portion of farmers reported moderate stress, primarily linked to the loss of household income and increased expenses. In a survey of ginger farmers from Loei province, Wannaprasert and Choenkwan [52] found that COVID-19 negatively impacted input supply chains, such as fertilizer and rhizome seeds, as well as the availability of international labor. However, in this case, there was a positive impact from COVID-19 in that ginger prices increased due to world market demand and the belief that ginger could be used as an antioxidant to prevent COVID-19 infections. This study also showed that the group of ginger farmers surveyed displayed a degree of resilience during the COVID-19 pandemic, as they relied less on markets to fulfill their own subsistence requirements. While the type and degree of impact may vary from farming community to farming community in Thailand, in general, our findings are consistent with the literature.

Flooding and drought were both identified in the preliminary list of disruptions. Despite experiencing the historic 2011 flood, our results indicate that water hazard was not the community's foremost concern. Sirisupluxana and Bunyasiri [53] reported in their survey of rice farmers in Pitsanulok and Suphanburi provinces that 64% felt fluvial flooding posed a high risk of impacting farm income, but 36% felt there was no or low risk. For the same study, only 37% of the farmers felt drought posed a high risk of impact to farm income while 63% believed drought represented no or low risk [53]. Khadka et al. [54] noted that Thailand is one of the most drought-affected countries in the Asia-Pacific region and is impacted by frequent droughts, with the probability of drought in Thailand for any given year being 45%. Khadka et al. [54] also reported that the drought episode of 2015–2017 caused an estimated damage of $3.3 billion country-wide. In the drier northeast region of Thailand, farmers appear to be well aware of drought consequences [55], while Babel et al. [56] recommended the construction of farm ponds at the household level, repairing existing irrigation projects to make them operable, implementing subsurface floodwater harvesting systems, shifting cropping dates, and switching to crops with shorter growing periods and less water requirement as measures to enhance drought resilience in the northeast. In our study area, because of the extensive Khlong system for irrigation, the pandan farmers may feel less concerned about the risk of drought.

Interestingly, [53] also found that more than half of the farmers implemented some type of flood prevention or mitigation action including building a flood protection system (building a road ridge or earthen dyke) and changing the cropping calendar (changing their cropping calendar to harvest before the flood occurred or using shorten-growing rice varieties). The study emphasizes that farmers in flood-prone areas have developed a high capability to cope with flooding, given its recurring nature almost every year [53]. Although these results were for a survey of rice farmers in different provinces than our study area, they seem to support our workshop findings that hydrometeorological hazards may be of lesser concern to the farming community than we had originally anticipated, but also may reflect that small-scale farmers may be less interested in or capable of implementing risk management measures. Furthermore, as noted, pandan generally is a more resilient crop to flooding than rice and this was one of the reasons for shifting to increased pandan production in the Khlong 3 area after the 2011 flood.

4.4. Community Resilience Characteristics

The third step in the CoBRA analysis framework was to develop outcome statements that describe resilience for all households in the pandan community. The same 4 teams broke out again and developed a list of outcome statements that ultimately were reduced to 8, based on further group discussion and ranking. Using the previously described ranking method, participants allocated their beans to prioritize the statements according to their importance. The consensus-based 8 resiliency outcome statements were grouped according to key dimensions within the UNDP framework: economic, social, environmental, and informational dimensions (Table 4).

The workshop results indicate that the pandan farmer community thinks the main characteristics of a resilient community involve an economic dimension. The listed statements underscore the significance of economic stability, emphasizing the importance of land ownership, financial security, and government support for community resilience. The highest ranking being given to “land ownership” emphasizes the importance of secure property rights in promoting economic stability within a community. This not only provides individuals with a sense of ownership and stability but also serves as a foundation for various economic activities. Small farmland ownership certainly is a contentious issue throughout Southeast Asia. Some (e.g., [57]) have argued that increased farm size needs to take place for the agricultural sector to remain competitive. Yet, others [58] offer another possible scenario: “Smallholders will continue to innovate, embrace the opportunities provided by new value chains (green, organic, high value), and construct their livelihoods across spaces and sectors”. “Financial security” is crucial for individuals and communities to withstand economic shocks and uncertainties. Financial stability enables better planning and preparedness, essential components of overall community resilience. The recognition of “Support from government agencies” signifies the role of external support in reinforcing economic stability. Government interventions, particularly from agencies like the Ministry of Agriculture and Cooperatives, can enhance the community’s capacity to cope with economic challenges. As noted, this group of farmers is a member of The Large Pandan Land Plot Program, which is an agricultural extension policy launched by the Ministry of Agriculture and Cooperatives in 2015. The benefits of joining this program are evidenced by a study of large-scale farming operations in the pilot area [59], which showed a reduction in production costs by 17.9% and an increase in productivity by 15.6%.

Table 4. Highly Ranked Community Resilience Statements.

Characteristics of a Resilient Community	Statement	Score
Economic Stability and Resources (72)		
Land ownership	• A household that has their own farmland.	34
Financial security	• A household that has multiple sources of income. • A household that has emergency savings. • A household that has enough money for a recovery plan.	24
Support from government agencies (e.g., Ministry of Agriculture and Cooperatives)	• A household that has access to resources provided by government agencies to support agricultural activities and cooperative initiatives. • A household that benefits from technical expertise and guidance offered by government agencies to improve agricultural productivity, enhance farming techniques, and address agribusiness development.	14
Community and Social Support (16)		
Support/synergy/cooperation within the community (Knowledge, material, technology, and market)	• Members of the household actively participate in knowledge-sharing networks, exchanging information, experiences, and best practices. • Community members collaborate to market their products collectively, leveraging economies of scale and accessing larger markets.	11
Medical services and facilities	• A community that has access to good medical services and facilities. • The household is in an area with adequate access to healthcare facilities such as hospitals, clinics, medical centers, and pharmacies.	5
Environmental Dimension (9)		
self-sufficiency farming	• A household that can produce local food at the family scale. • A household that practices resource-efficient gardening or farming methods such as mulching, composting, or organic fertilization.	5
Water storage and retention areas	• A household that collects and stores rainwater, retention ponds, or basins for home use and in farm irrigation. • A household that has installed rainwater collection systems.	4
Information Dimension (5)		
Data, news, and knowledge	• A household that stays informed and updated on critical news. • A household that has access to a variety of reliable news sources.	5

The second dimension identified to characterize a resilient community is community and social support. Workshop participants emphasized the collaborative nature of resilience-building, encompassing knowledge exchange, material support, technological advancements, and access to markets. Strong community ties foster collective responses to challenges. The health infrastructure in promoting community well-being is important as well. Accessible healthcare contributes not only to the physical health of community members but also to their overall resilience in the face of health-related challenges. Although Thailand implemented a universal health care program in 2001 that has greatly improved access to medical facilities [60], and quite adequate coverage can be obtained for 500 thb per month, Ref. [61] noted that some rural communities continue to have inequitable access to health care. Still, catastrophic economic impacts on families experiencing health challenges have declined [62].

The environmental dimension was the third broad factor identified, specifically in relation to local food systems and water accessibility. Community resilience is closely tied to food security and local production reduces dependence on external sources, contributing to long-term sustainability. Reliable access to water resources is essential for agriculture, sanitation, and overall community sustainability, especially in regions prone to water scarcity or extreme weather events.

Information and knowledge level emphasizes the role of information in community resilience. Timely and accurate information enables communities to make informed decisions during crises, enhancing their ability to adapt and respond effectively.

4.5. Trend or Change in Achievement of Resilience Characteristics

Using a 5-point Likert scale, the workshop participants assessed changes in the outcome statements over the past 5 years and the results are summarized in Figure 5. The mean Likert scores in Figure 6 indicate that the majority of the 8 outcome statements are greater than the "same as before" classification, congregating close to the "slightly better than before" classification. The exception to this trend is "financial security", which is on the lower side of "same as before".

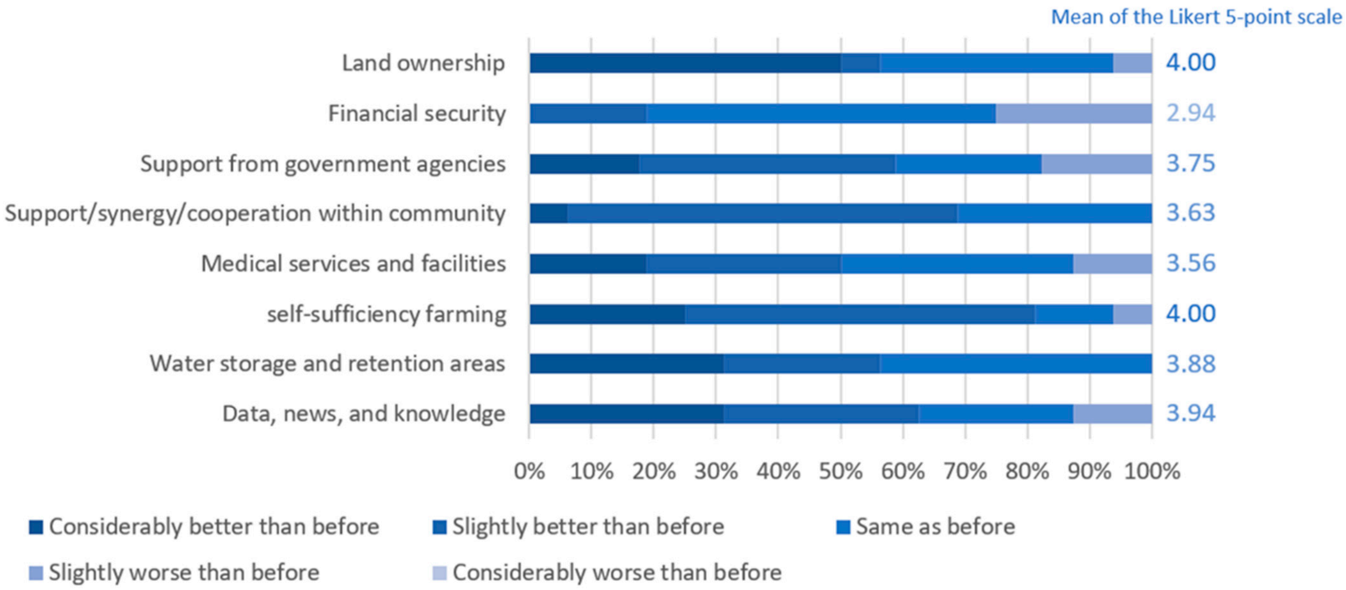

Figure 5. The trend or change in achievement of resilience characteristics in the past 5 years.

Based on the characteristics of a resilient community, along with the self-assessment of progress made in the past 5 years, we can conclude that, overall, the community has made positive progress towards improved resilience, with notable achievements in land ownership (4.00), self-sufficiency farming (4.00), data, news, and knowledge (3.94), and support/synergy/cooperation within the community (3.63). However, there are still areas, such as financial security (2.94) and medical services and facilities (3.56), where further efforts may be needed to enhance resilience.

Workshop participants were asked to score the extent to which they had achieved their priority characteristics of resilience. They scored each statement twice: first for the current period and second for the disruption period (which had been voted by the participants to be the COVID-19 pandemic). The scores were ranked on a scale from 0 to 10, with 10 being perfect attainment of that characteristic, and 0 being no attainment.

In analyzing the trends (Figure 6) between increased and decreased scores for resilience characteristics before and during the disruption period (COVID-19 pandemic), it is evident that self-sufficiency farming saw an improvement, with the score increasing from 7.47 before the crisis to 7.93 during the pandemic. This suggests an increased resilience in food production and self-reliance efforts amid the challenges posed by the pandemic. Conversely, several characteristics experienced declines during the crisis. Land ownership decreased from 7.53 before the crisis to 6.33, indicating potential challenges or disruptions related to land ownership. Financial security also saw a decrease, dropping from 8.40 before the crisis to 6.07 during the pandemic, highlighting vulnerabilities or hardships in financial stability. Additionally, support, synergy, and cooperation within the community decreased from 7.93 before the crisis to 6.40, indicating strains on community relationships and collaboration. Access to data, news, and knowledge decreased from 7.47 before the crisis to 6.47, suggesting potential disruptions in information flow or access. Medical services and facilities decreased from 6.60 before the crisis to 5.13, indicating challenges or strains on healthcare services. Finally, water storage and retention areas decreased slightly from 7.13 before the crisis to 6.67, suggesting challenges in managing water resources. These declines underscore potential vulnerabilities and challenges faced by the community during the COVID-19 pandemic, emphasizing the need for targeted interventions to enhance resilience in the future.

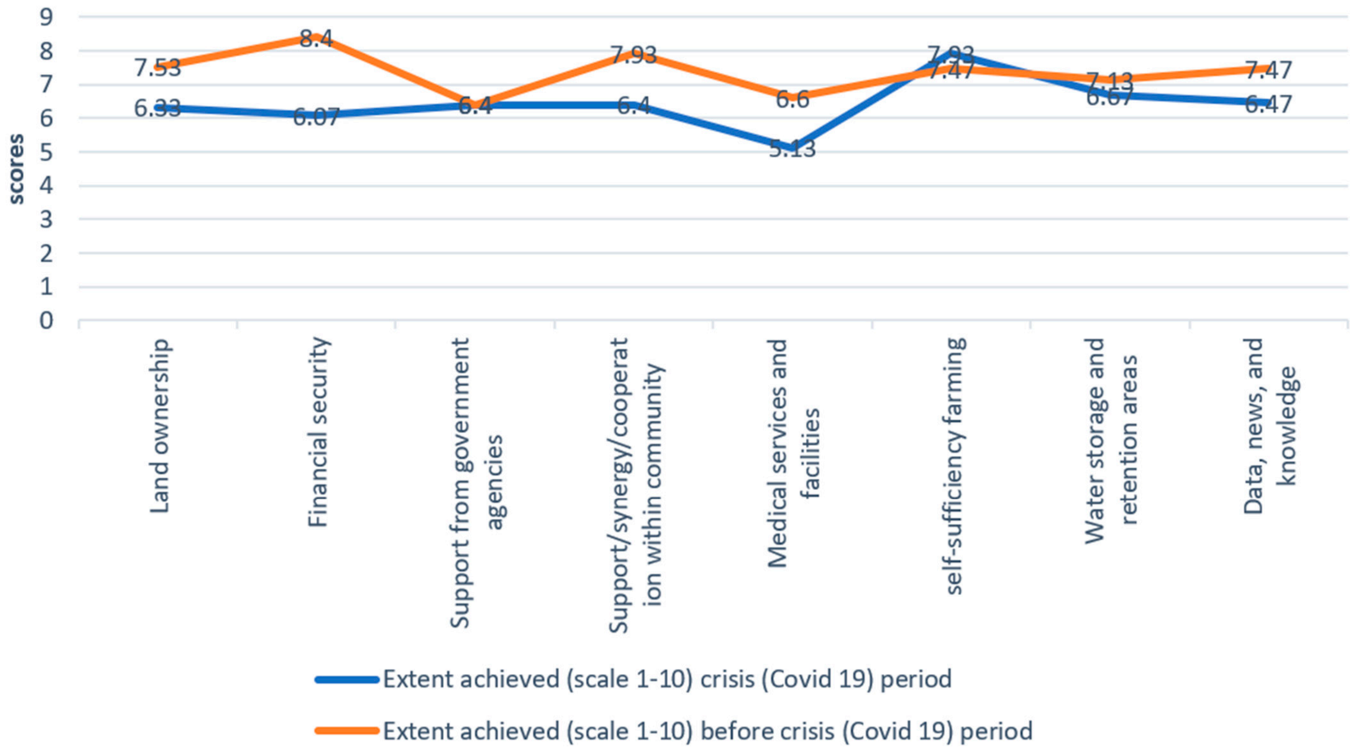

Figure 6. The community's progress in developing resilience characteristics before and during crisis periods.

Education, water, and health care are the top three interventions that contributed to household resilience in the Community-Based Resilience Analysis in the Horn of Africa [25]. The implemented measures mirror the prioritization of these factors as resilience characteristics by our workshop participants. Water-related interventions were notably emphasized, primarily to enhance food security and livelihoods. These encompassed initiatives aimed at expanding water sources and storage facilities, such as installing household tanks, ponds, or communal water pans. Education was viewed not only as an intrinsic benefit but also as a pathway to improved life prospects, including enhanced employment opportunities for children. Interventions like scholarships, financial aid, and access to boarding schools were frequently highlighted as crucial for ensuring children's completion of higher levels of education. Health-related interventions were similarly deemed indispensable. The illness of a household member was recognized as a potential threat to household resilience, often resulting in a significant loss of productivity. The impact of poor health on the resilience of rural families has been reported throughout Southeast Asia [21,26].

4.6. Pathways to Resilience

A resilient community is one that can effectively adapt, withstand, and recover from various challenges and adversities. Based on the responses from workshop participants in this study, the key resilience characteristics of peri-urban agricultural communities are outlined as follows:

Economic Diversification: Resilient peri-urban agricultural communities promote economic diversification and local self-reliance to reduce dependence on external factors and mitigate the impact of economic shocks. Farmers, particularly in regions prone to weather-related challenges, tend to seek non-farm income sources [58]. Engaging in non-farming and off-farm activities can significantly increase their income [63]. Additionally, changing farming systems to reduce the need for water can make them less vulnerable to drought. For example, this may involve cultivating drought-resistant crops, implementing drip irrigation systems, adopting conservation tillage practices, and utilizing rainwater harvesting techniques. Exploring agro-tourism and developing value-added products also can contribute to a more resilient economic base.

In our study community, a second workshop was delivered in which we explored the development of new pandan products (Figure 7a). Each group at the workshop brainstormed potential pandan products to be developed in the future and their discussions included the product, production process, price, and place. Group 1, for example, was interested in healthy pandan tea (Figure 7b). They felt the product mix should consist of pandan tea and pandan tea mixed with rice, similar to Genmai Cha Japanese Tea, for which the wholesale price is 150 baht for 30 pieces and 220 baht for 30 pieces retail. Market analysis and potential marketing strategies subsequently were conducted for an organic pandan tea [64].

Figure 7. (**a**) display of existing pandan products at the workshop sign-in desk; and (**b**) product development brainstorming at the workshop.

Strong Social Networks: Resilient communities have strong bonds among residents, characterized by trust, mutual support, and cooperation. These social connections enable individuals to access resources, share information, and provide emotional support during times of crisis. When people within a community are interconnected and supportive, they can effectively collaborate to overcome challenges, whether it is recovering from natural disasters, dealing with economic downturns, or facing other difficulties. Therefore, fostering and nurturing social networks within the peri-urban agricultural community is crucial for building resilience and ensuring the well-being of its members. To a great extent, this role is played by the formal pandan farming group, led by the elected village headman (a woman). As the village headman, she plays a central role in the community. Her position allows her to have strong relationships with all the households, making her a key figure in community coordination. Additionally, her home serves as a gathering place for the community, further solidifying her importance in bringing people together.

Effective Healthcare Systems: Peri-urban areas often face challenges in accessing formal healthcare facilities. These communities require educational materials in local languages and culturally appropriate formats to ensure widespread understanding and compliance with health guidelines. Furthermore, establishing easily accessible healthcare infrastructure, such as testing centers, vaccination sites, and telemedicine services, can enhance the community's capacity to promptly diagnose, treat, and manage COVID-19 cases. As part of a WHO-sponsored workshop, Ref. [65] examined the COVID-19 management experience of three communities in the BMA and BMR. They found that the rural community in the northern part of peri-urban Khlong 3 (a similar area to our study) generally was spared from major outbreaks because of their relative isolation and careful precautions, but that the more urbanized peri-urban area of Khlong 3 to the south did experience greater infection rates. The local district organized COVID-19 screening and transport for infected cases to the nearby hospitals, as well as establishing a temporary, purpose-built isolation facility in the vicinity. Despite these relative successes, the workshop participants recommended and designed a multiple-disease treatment center. Flexible healthcare systems, including mobile clinics, telemedicine services, and community health workers, are essential for providing healthcare access during pandemics and other healthcare emergencies to enhance resilience in both higher-density and lower-density peri-urban areas.

Secure Land Tenure: Land ownership stability is a critical characteristic of resilient peri-urban agricultural communities in Thailand. In the case of small rice farms with full land ownership, yields can potentially double compared to those with weak land ownership and reduce the informal debt of farm households [28]. Clear and secure land tenure provides residents with a sense of ownership, encouraging long-term investments in disaster mitigation measures and community infrastructure. In the context of health crises like COVID-19, secure land tenure facilitates the establishment of essential healthcare facilities and services, ensuring equitable access to healthcare for all residents. Secure land tenure and property rights are fundamental to accessing adequate housing, food security, and livelihoods. Land tenure security is crucial for the realization of human rights, poverty reduction, economic prosperity, and sustainable development.

Information Awareness and Adaptability: A key characteristic of resilient individuals and communities is their commitment to staying informed and updated on critical news and events. By actively seeking reliable sources of information and remaining aware of changing circumstances, resilient individuals can adapt their plans and responses to emerging challenges. This proactive approach enables them to make informed decisions, take appropriate actions, and effectively navigate uncertainties, ultimately enhancing their ability to withstand and recover from various disruptions, including natural disasters, health crises, and socio-economic challenges. Resilient communities foster a culture of continuous learning, innovation, and adaptation to stay ahead of evolving challenges and seize opportunities for improvement. This involves monitoring trends, evaluating outcomes, and sharing best practices to enhance resilience and build a more resilient future. For the pandan community, this role was led by the village headman who was the point of contact between the community and government outreach programs (e.g., securing and demonstrating pandan drying ovens, enhancing the capability of community-based agrotourism).

Water Security Infrastructure: An essential characteristic of resilient agricultural communities is the availability of water storage and retention areas. These infrastructure components ensure access to clean water during times of scarcity, such as droughts or disruptions to the water supply. By investing in reservoirs, rainwater harvesting systems, and retention ponds, communities can mitigate the impacts of water shortages and enhance their resilience to climate-related hazards. Adequate water storage capacity not only supports essential needs like drinking water and sanitation but also enables communities to sustain agricultural activities and mitigate the risk of waterborne diseases during emergencies. Thus, access to water storage and retention areas plays a crucial role in safeguarding community well-being and promoting resilience in the face of environmental challenges. For our study area, there seems to be less urgency for storage areas because of the existing irrigation canal network. Indeed, rice farmers in this area have been observed to grow up to four crops per year. However, ref. [66] recently explored an innovative approach to real-time control in managing the surface storage pond areas and Khlongs within the Tung Rangsit study area with the objective of improving irrigation and drainage system operation to reduce flooding and provide a more equitable water distribution between the Khlongs and retention areas that could provide additional water storage for agricultural purposes. This type of real-time operation would require close coordination between the peri-urban agricultural communities, the Thai Irrigation and Drainage Department, and the municipal government. Such collaborative potentials are emphasized in the next section. Finally, we would like to note that the farming community does not pay for the irrigation water, but there is a movement in the Thai government to initiate a system of user fees. It is still unclear how these changes might impact peri-urban agricultural community resilience.

Governmental Support and Collaboration: Resilient communities (agricultural and otherwise) benefit greatly from strong collaboration with government agencies and local governments. These agencies provide essential resources, expertise, and guidance during challenges like natural disasters, economic downturns, and public health crises. By actively partnering with local authorities, government agencies help develop effective disaster preparedness, agricultural resilience programs, and community initiatives. This support enables communities to access crucial resources, funding, and technical assistance, enhancing their ability to adapt, recover, and prosper in difficult times. Government interventions, such as provincial agricultural projects, have proven vital for pandan farmers, mitigating flood risks and supporting sustainable farming practices through initiatives like low-cost fertilizer projects and improved distribution channels.

Food Self-Sufficiency and Local Production: A key characteristic of resilient households and communities is their ability to produce local food. By cultivating home gardens, raising small livestock, and practicing sustainable agriculture, households can enhance their food self-sufficiency and resilience to external disruptions. Local food production reduces dependence on external food sources, mitigates the impact of price fluctuations and supply chain disruptions, and ensures access to fresh and nutritious food during times of crisis. Moreover, it promotes environmental sustainability, fosters community connections, and contributes to food security at the local level. By empowering individuals and households to produce their own food, communities can build resilience, adaptability, and sustainability in the face of various challenges, including economic uncertainties, natural disasters, and public health emergencies.

5. Conclusions

Our study employed the Community-Based Resilience Analysis (CoBRA) tool to investigate the resilience of a peri-urban pandan farming community to self-identified disruptions, with a focus on COVID-19. To our knowledge, this is the first application of CoBRA in Southeast Asia. The peri-urban pandan community selected COVID-19 as their disruption of greatest concern, although they also identified water quality and solid waste management as being of secondary concern. The farming community generally was aware of climate change issues, but hydro-meteorologic disruptions generally seemed to be of lesser concern.

Based on their own resilience assessment statements, the pandan peri-urban community believes it has made positive progress towards improved resilience over the past 5 years, with notable achievements in land ownership, self-sufficiency farming, data, news, and knowledge, and support/synergy/cooperation within the community. However, aspects of financial security and medical services and facilities need to be improved to enhance resilience. COVID-19 had a negative impact on resilience according to the Co-

BRA community resilience assessment statements, with the exception of self-sufficiency farming (slight positive impact) and support from government agencies (a neutral change). The recognition of economic stability and resources, community and social support, environmental dimensions, and information dimensions by the community as key resilience characteristics highlight the comprehensive approach necessary for planners and communities to enhance hazard resilience in peri-urban agricultural areas. Furthermore, a disruption like COVID-19 may weaken the resilience of a system, making it more vulnerable to different disruptions in the future. In this sense, we would note that while the community chose to assess resilience based on COVID-19 as the primary disrupting agent, in fact, a number of the community-identified resilience statements also would address resilience to other identified potential disruptions, including floods and droughts (e.g., water storage and retention areas; support from government agencies; support/synergy/cooperation within the community). To address future challenges in peri-urban agriculture, it is imperative to focus on enhancing economic diversification, strengthening social networks and support systems, implementing sustainable land management practices, and promoting access to timely and accurate information. Additionally, investing in infrastructure for water management and waste recycling, supporting small-scale farming initiatives, and fostering collaboration between farmers and local authorities are essential for building resilience in peri-urban agricultural communities. Our follow-up workshop illustrated that the community was interested in developing new, innovative pandan products that could increase economic resilience. The pandan community structure, led by the elected village headman, also enhanced resilience by facilitating information dissemination and communications with government agencies.

Some shortcomings of the study should be noted. First, the COVID-19 disruption itself provided a challenge to arranging and delivering the face-to-face workshops. Concerns about COVID-19 may have limited the participation of some members of the pandan community. Second, it would have been valuable to conduct in-depth, semi-structured follow-up interviews with families to identify successful individual resilience strategies. Finally, we see both a strength and a shortcoming in the CoBRA methodology. While it is beneficial to allow the community to express its visions regarding primary disruptors and characteristics of community resilience to these disruptors, we note that the community decision in selecting COVID-19 as the primary disruptor likely was influenced by immediate experience with the pandemic. In our subsequent applications of CoBRA for other agricultural and residential communities in Thailand and residential communities in Malaysia, COVID-19 has been noted but not selected as the primary disruptor. It must be recognized that in a longitudinal study of the same area, the identified disrupting event may change over time. This non-stationarity of disrupting events can complicate longitudinal comparisons.

Overall, this research contributes to the growing body of knowledge on peri-urban agricultural practices and resilience, providing insights and recommendations for policymakers, practitioners, and stakeholders involved in sustainable urban planning and agricultural development. By prioritizing the resilience of peri-urban communities, we can foster inclusive and sustainable growth that benefits both urban and rural populations in the face of evolving environmental and socioeconomic challenges.

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