Integrating indigenous knowledge for participatory land use planning (PLUP) in Tra Hat hamlet, a climate-smart village in the Mekong River Delta, Vietnam

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Abstract:

Agriculture is a primary source of livelihood in the Vietnamese Mekong River Delta with different land use activities. There are different potential conflicts in agricultural land use, including: water resources use and interests. Therefore, establishing feasible land use planning (LUP) in an area needs an in-depth participation and discussion among stakeholders (including: governments at different levels, local farmers, and national and international scientists). Indigenous knowledge of local farmers plays an important role in making land use decision, which can support solving land-use conflicts to achieve the most sustainable management of land resources. In this study, we integrated local knowledge into a land use planning process to assess the suitability of land use types and to project potential impacts of climate change conditions on land use decisions in the Tra Hat hamlet, one of the climate-smart village (CSV) sites in the Vietnamese Mekong River Delta. A total of two consultation meetings, using simple tools (resources mapping, timeline, seasonal calendar, wealth ranking, Venn diagram, pair wise ranking, and key informants' interviews), were conducted, and 130 households were interviewed during a field visit in 2015. As a result, a participatory land use planning (PLUP) was implemented with active participation of the concerned communities to establish a suitable land use planning and identify the potential adaptation techniques in the near future (2020). Land use planning at the hamlet was discussed to get the agreement and the coordination among local governments, farmers and scientists on adaptation practices.

Keywords: ***climate-smart villages, land use planning, participatory, the Vietnamese Mekong River Delta, Tra Hat hamlet.***

Classification number: ***3.1***

Introduction

CSV is a definition developed by the CGIAR research program on climate change, agriculture and food security (CCAFS), and Tra Hat hamlet is one of the CSV sites in Vietnam. These are sites where researchers, development partners, and farmers come together to test climate-smart agricultural interventions. The aim is to boost farmers' ability to adapt to climate change, to manage risks and, to build resilience. At the same time, the hope is also to improve livelihoods and incomes, and where possible, to reduce greenhouse gas emissions to ensure solutions are sustainable [1].

The villages are being set up in areas that have been identified as being high at risk from the effects of climate change, and where partners are already conducting work. Prior to the project start-up, a steering group made up of researchers and village representatives identify 'climate-smart' interventions best suited for that community. The list of activities is introduced to a group of farmers and village officials. The group prioritizes the different technologies based on yield and resilience potential, as well as other features they find useful. If accepted, the rest of the community gets to weigh in on the project. The process aims to be as participatory and inclusive as possible, especially to encourage women and more vulnerable groups to

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participate. Researchers and farmers continuously monitor and evaluate the activities. These actions are to gain a full understanding of the benefits and effects they might have on farm production, income, resilience, equity, employment, adaptation, and mitigation. The aim is to scale-up the practices [1].

Indigenous knowledge of local communities can provide an important tool for early detection and understanding of the impacts of production condition changes [2]. Exploring Indigenous knowledge through group discussion is important to work to support the research group to understand the study area when the study began in local communities. Because field surveys can be time- and cost-intensive, early detection efforts are limited [2]. The benefits of integrating local ecological knowledge with the Western science are widely espoused. Examples demonstrate how this process can inform adaptive ecosystem management [3], facilitate effective co-management between resource users and land managers, and afford a more holistic understanding of a given system [4]. Local livelihoods are strongly influenced by the effects of human land use [5]. The competing land uses which are present in the river basin may further amplify the cumulative negative effects of land use changes at the local and landscape scales [2]. PLUP is an iterative process based on the dialogue amongst all stakeholders aiming at the negotiation and decision for a sustainable form of land use in rural areas as well as initiating and monitoring its implementation [6]. PLUP is essentially bottom-up land-use planning, carried out with the active participation of the concerned communities [7]. Through the process of PLUP, the communities achieve a consensus on the sustainable management of their natural resources [6]. As one of the first steps of PLUP, a participatory rural appraisal (PRA) is carried out in every village, and a trained multidisciplinary team analyzes the situation on hand with the local beneficiary groups and stakeholders. A series of methods are applied to acquire and analyze information, including participatory surveillance, transect walk through the kebele, ranking and scoring as well as cropping calendars. Finally, the PRA survey leads to a number of group discussions, where the target groups identify and prioritize the problems, activities, and areas of intervention. As a result, a participatory village map is created during the discussion. The information collected from the PRA and field surveys forms the basis of local knowledge of a village [6]. Under the current and future climate change, PLUP must be intended to incorporate possible climate change (and sea level rise, if relevant) into the identification and selection of land use options. Such participatory land use planning under climate change (PLUP-CC) should not only improve the livelihoods of the existing community but also sustain the resources development of the future generation [7]. In 2015, village baseline studies were conducted to analyze general local conditions. After that, a training and implementing for PLUP were conducted in Tra Hat hamlet to improve the capacity of staffs (CTU and PLUP) in PLUP.

The study aims at (1) assessing the utility of local indigenous knowledge in exploring basis problems in the study area and (2) integrating local indigenous knowledge with PLUP to map the suitable areas of land use types adapted to CSV purposes.

Methods

Study area: Tra Hat hamlet located in Chau Thoi commune, Vinh Loi district, Bac Lieu province, Mekong River Delta is one of the CSV sites in Vietnam of CGIAR program - CCAFS. The area is also in the highly vulnerable agricultural ecosystems zone (AEZ) of the Vietnamese Mekong River Delta due to sea level rise and climate change (Fig. 1). The hamlet has 301 households with

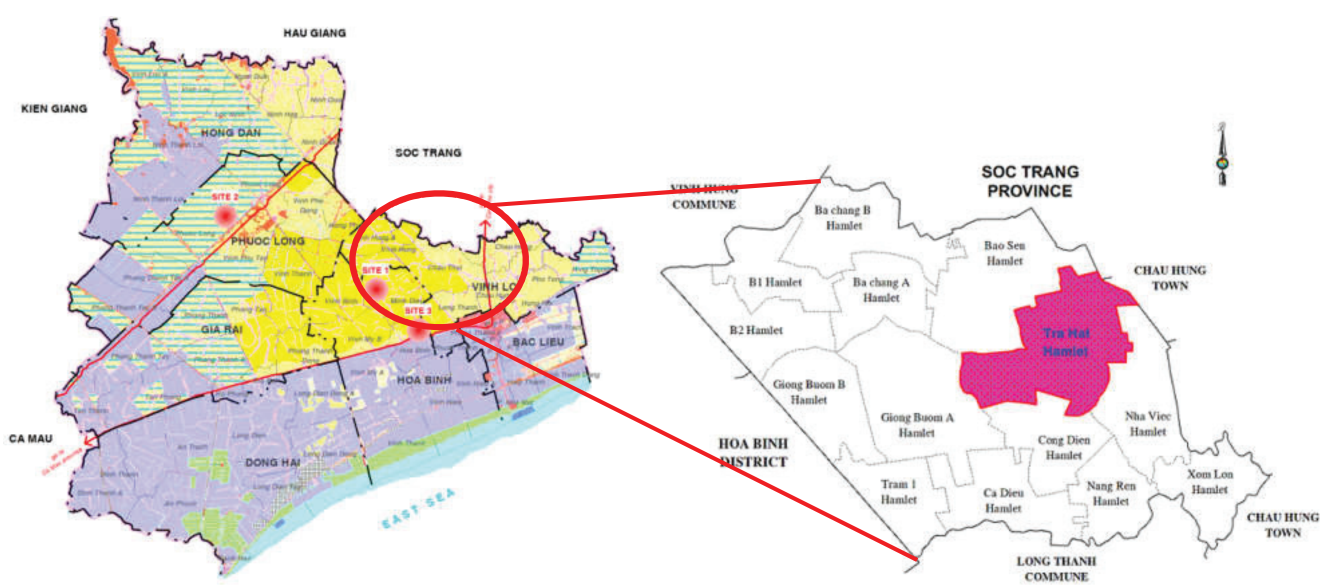


Fig. 1. The study area of Tra Hat hamlet, Vinh Loi district, Bac Lieu province.

main livelihoods depending on rice and home-garden (including upland crops, small-scale livestock and aquaculture). Tra Hat hamlet is inside Quan Lo Phung Hiep - a salinity control project area, and its agriculture is facing lack of fresh water and salinity intrusion during the dry season. Moreover, in the rainy season, low-lying areas of the hamlet are inundated, and the situation would be more serious in the future under the impacts of climate change and sea level rise (CC&SLR) [8]. Besides, the income of villagers is fluctuating due to not only the unpredictable water condition, such as surface water salinity intrusion and change of rainfall pattern but also unstable prices [9].

Data collection: Two consultation meetings were organized (20 participants). The list of participants was compiled by the head of village and gender was balanced among the participants (10 males and 10 females). 240 randomly selected household interviews were conducted to identify the impact factors on local agriculture and the interviewees were asked to rank these selected parameters on a scale of 1 to 5, in which 5 refers to high impact (severe), and 1 refers to very low impact (Table 1). The perceptions (scale) of relevant indicators were summed to estimate the overall scores of factors.

Framework

The PLUP process is mainly based on FAO methods including land evaluation and land use planning [11, 12], and the community agro-ecosystem analysis [13]. The process consists of five steps.

The process of PLUP-CC and sea level rise (SLR) consists of four steps.

In this study, the participatory land use planning session completed four tasks:

1. To conduct PRA workshops to identify and map the farm types based on land use systems and locations, and to review the past, current and near future (five years) of bio-physical and socio-economic changes.

Table 1. Impact categories and their range [10].

Rank	Impact categories	Magnitude	Level impact
5	Severe	4.1-5	> 20%
4	High	3.1-4	15 - < 20%
3	Moderate	2.1-3	10 - < 15%
2	Low	1.1-2	5 - < 10%
1	Very low	1 and below	< 5%

2. To quantify existing farm-type land uses' inputs/outputs via farm surveys and interviews.

3. To assess impacts of biophysical and socio-economic changes on the current and future land uses patterns.

4. To conduct workshops for screening potential adaptation strategies (organizing participatory consultation meetings between experts, planners and villagers to provide information and discuss potential adaptation measures based on the past and current experiences).

Results and discussions

Indigenous knowledge in identifying local resources

Land resources, water resources, and climate factors which impact on local land uses were specified. The hamlet's topography is rather stable. The ground elevation in low areas is not much different from in high areas. Local farmers assess the soil condition of Tra Hat as being in good condition (Fig. 2). Thanks to the well-built irrigation system and sluice gates, the soil's salinity and acidity are kept at a low level. However, in the dry season, when

Fig. 2. Training indigenous knowledge of integration in the PLUP process to local farmers. (A) A group of farmers focused on inspecting local resources, land use changes, climate issues and land use planning complement; **(B)** Identifying land qualities via participatory field survey in each AEZ; **(C)** Local farmers identified local resources during participatory mapping activities; **(D)** Group discussion with stakeholders on achieved results.

less water available, there are risks of acidity in some local areas.

The hamlet is located in freshwater ecological zones where closed dyke and sluice gates system are completely constructed. Both surface water and groundwater are the main sources of domestic water supply and agricultural production. Rainwater is used during the rainy season. In other periods, the main sources of water are provided by local canals (at rice producing area) and groundwater (at upland crop area). River flood hardly happens in the hamlet because it is located closely to the East Sea. However, water shortage in the dry season is still a problem in the area.

Tra Hat hamlet can be divided into four Agro-ecosystem zones (AEZs) (Fig. 3) that is characterized by high levels of topographic, soil fertility and land-use types. These zones share a boundary which is the local canals system.

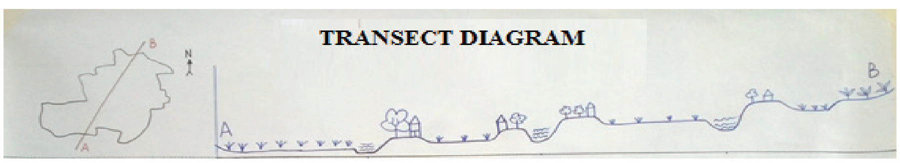
Present land use assessment

The historical land use change (Table 2) shows that Tra Hat had rather a stable land use; most of the farmers cultivate traditional rice. Land use change process in the hamlet depended on the changes of physical conditions (salinization, irrigation system) and was driven by desires to increase income.

However, the improvement of rice production (increasing crops) has resulted in different problems. Soil becomes swampy because of intensive cropping. The farmers need to supply more fertilizer and pesticide. Therefore, the capital and price are increased, but the products' quality is decreased. Besides, fertilizer and pesticide residue also leaves negative effects on land and water environment.

Local farmers do not want to change their cropping pattern; they are afraid of facing incurred risks. Rice monoculture is a disadvantage since rice market and its price fluctuate overtime. Moreover, they have not had experience in producing other cropping patterns (except rice production). Thus, they found it difficult to change into new cropping patterns, which could adapt to climate change and market fluctuation in the future.

In Tra Hat hamlet, agriculture is the primary source of livelihood, in which, the rice production occupies a large area while the rest is of the upland crop production. There are 310 households in the hamlet, in which 97.1% produces rice (including 93.3% double-rice crops and 6.7% triple-rice crops) and only 2.9% produce upland crops. The hamlet also has other agricultural activities but they keep a small percentage of the total area of the village such as small-scale livestock, orchard and aquaculture. These kinds of production did not get the interest of local farmers because of low (existing) farming techniques, limited labour and limited capital capability as well as farmers' risk aversion to land-use changes. Therefore, these kinds of production do not lead to an increase in household income as they should. In general, the farming patterns in Tra Hat are still intensive. Currently, three main land-use types are distributed in four AEZs in the hamlet (Fig. 4) including Triple-rice crops (at AEZ I); Double-rice crops (at AEZ II & III); Upland crops (AEZ 4).



AEZ	I	II	III	IV
Current land use	Triple- rice crop	Double-rice crop	Double-rice crop	Upland cop
Topography	Low	Slightly Low	Medium	High
Soil fertility	Rich	Rich	Medium	Medium
Deep flooding	30cm	30cm	No flood	No flood
Water	Not enough Irrigated for dry season	Not enough Irrigated for dry season	Not enough Irrigated for dry season	Enough Irrigated

Fig. 3. Tra Hat transect diagram drawn based on topography, ascending from the South-West to North-East.

Table 2. Historical land use change.

Event history	Before 1990	1990-1994	1994-2015
Land use change	Paddy rice (Mono-rice crop)	Double-rice crops	Triple-rice crops
Rice varieties		IR42, OM545, Tai Nguyen	Short-time varieties, Tai Nguyen
Reason of transform	Salinized	invested sewer systems	increase income

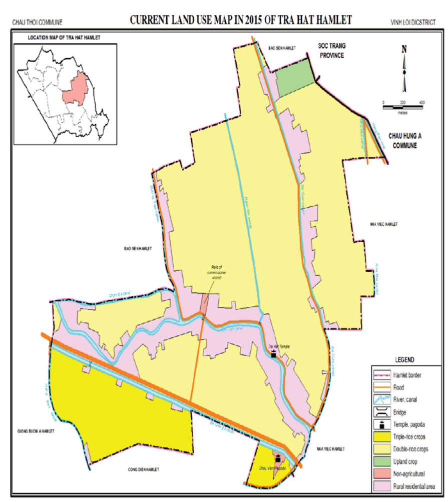


Fig. 4. Present land use map of Tra Hat hamlet in 2015.

Table 3. Inputs and outputs of existing land use systems.

Indicators	Double-rice crops (Million VND/ha/year)	Triple-rice crops (Million VND/ha/year)	Upland crops (day/ha/year)	Orchard (Million VND/1000 m²/year)	Aquaculture (Million VND/1000m²/year)	Livestock (Pig) (Million VND/1000m²/year)
Cost	57.58	102.99	163.76	1.60	14.05	4,106.62
Revenue	49.39	43.10	152.91	0.54	15.07	1,215.46
B/C	0.86	0.42	0.93	0.34	1.07	0.30
Labour	129	163	690	21.00	126.00	4,166.67

Note: the majors included double-rice crops, triple-rice crops, and upland crops.

Table 4. Pair-wise ranking.

	Double-rice crops	Triple-rice crops	Upland crops
Double-rice crops			
Triple-rice crops	Double-rice crops		
Upland crops	Double-rice crops	Triple-rice crops	
Ranking	**1**	**2**	**3**

Table 5. PLUP suitability and selection.

AEZ	Current land use	PLUP suitability			Selected
		LUT 1 (Double-rice crops)	*LUT 2 (Triple-rice crops)*	*LUT 3 (Upland crops)*	
I	Triple-rice crops	3	2	2	Double-rice crops
II	Double-rice crops	2	2	0	Double-rice crops
III	Double-rice crops	3	1	2	Double-rice crops
IV	Upland crops	3	1	3	Double-rice crops/ Upland crops

Note: levels score - 0: not suitable; 1: marginally suitable; 2: moderately suitable; 3: highly suitable.

Table 6. Current exposure (in 2015) to extreme weather events.

Events	Duration	Description
Heavy rain	September-October	More rainy than usual
Drought	March- April	Acidification, cracked soil, dried up river, absence of rain
Rainstorm /high wind	May-October	Strong wind, collapse cultivation
Hot spell	March-April	Hotter (following weather forecast are 38-39^{0}C)
Saline intrusion (forecast)	February - April November - December	Saltwater, withered crops

Local land-use types are distributed differently periodically (Fig. 5). Regarding to the double-rice drop, it is cultivated in the Summer-Autumn season (June - September), using short-day varieties, and in the Winter-Spring season (October - March), using local long-day varieties (Tai Nguyen). Therefore, when farmers produce double-rice crops, they have about three months (March - June) considered as leisure time and they can use this leisure time to increase their income with others activities. Triple-rice crops (Summer-Autumn, Autumn-Winter, Winter-Spring; using short-day varieties) and upland crops have the cultivating time of all year round. From surveys and interviews with 130 households, the inputs/outputs data of land-use types are shown in Table 3.

Formulation of LUT options, and selecting preferable and feasible land-use types (LUTs) in AEZs in present condition

Promising land-use types (LUTs) are chosen by local farmers. They only recommend current land-use types which are considered suitable in local condition. Consequently, it is not diversified in selection. Priority of land-use types is presented in Table 4, including: (1) Double-rice crop, (2) Triple-rice crop, (3) Upland crop.

PLUP suitability, selection and mapping

The land suitability classification is performed by the local land users, which is based on the participatory land evaluation (FAO, 1976). Depending on land use demand, land-use types' suitability is assessed by local land users (through four levels of score) to define whether it is potential or not. The results of current land suitability evaluation are presented in Table 5, Fig. 6.

Identifying Climate change and sea level rise (CC-SLR) issues

Agricultural activities are seriously affected by changes in climatic pattern.

Table 7. Local adaptation strategies in 2020-2025.

	Heavy rain	Drought	Rainstorm/ Strong wind	Hot spell	Saline intrusion
Before	Preparing land and checking drainage system	Embankment or storage water, preparing tools and diesel to pump water	Spraying pesticides	-	Warning for production, saving fresh water
During	Opening sluice, sewerage in fields	Pumping water from river, killing hamsters	-	-	Testing water before irrigation, finding fresh water resources
Immediately After	Keeping the dry fields, Fertilizing and spraying pesticides	Fertilizing	-	Replanting when cultivation is wilted dead	-
Future	Reinforcing and building irrigation system and pumping system	Dredging canal, lakes; finding, planting and breeding	Breeding strong stems, potassium fertilizer and spraying "Lun" pesticides	-	Using short-day varieties, Changes of season calendar, Land use changes

Local farmers struggle with extreme weather events, including: Heavy rain, drought, rainstorm/strong wind, and hot spell. In addition, salinity intrusion is also another significant problem in the future. List of exposures to extreme weather events is described by local farmers (Table 6).

Revising promising land use types (LUTs) to adapt to CC-SLR

To deal with the effects of climate change, the farmers use indigenous knowledge effectively to adapt to changes and reduce risks and damages for agriculture and Table 7 presents strategies of local farmers. There are different solutions which would only be beneficial in a short term but bring unexpected risks in a long run (e.g. saline intrusion and drought).

Impact factors on agricultural production

The results of data analysis show that six factors were identified which impact local agricultural production (Fig. 7). These factors were assessed by indigenous knowledge with levels of effect ranging from 5 (severe) to 1 (very low).

LUP in CC-SLR conditions

Under the assumption that salinization would happen in Tra Hat in the future (2025), according to local farmers, salinization is a vital factor which affects the adapting capacity of land-use types. Potential land-use types are evaluated again by land user's knowledge. In salinization condition,

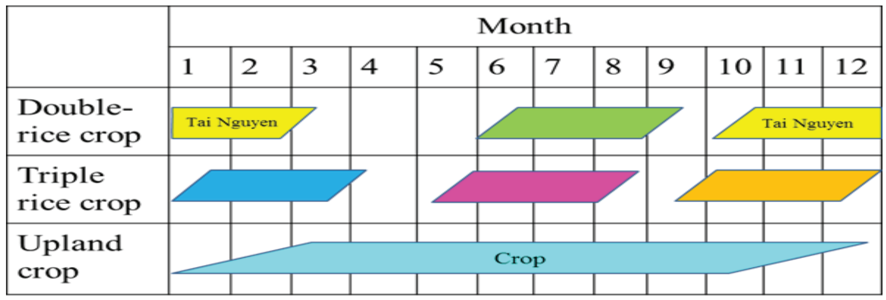


Fig. 5. Seasonal calendar of main land-use types.

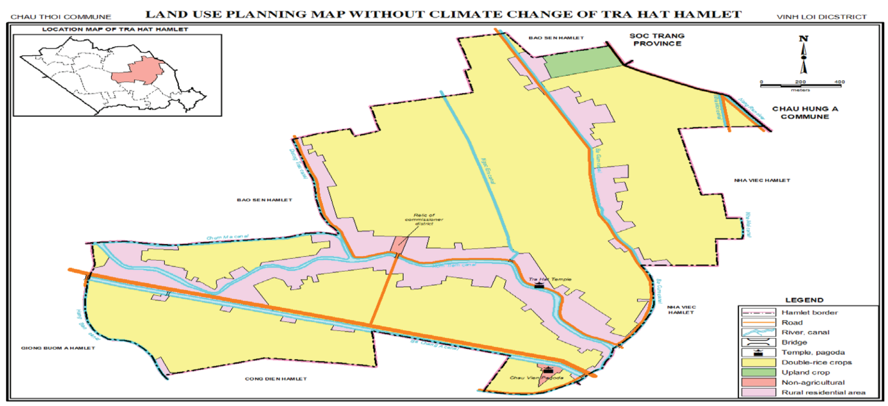


Fig. 6. Land use planning map without climate change of Tra Hat hamlet in 2020.

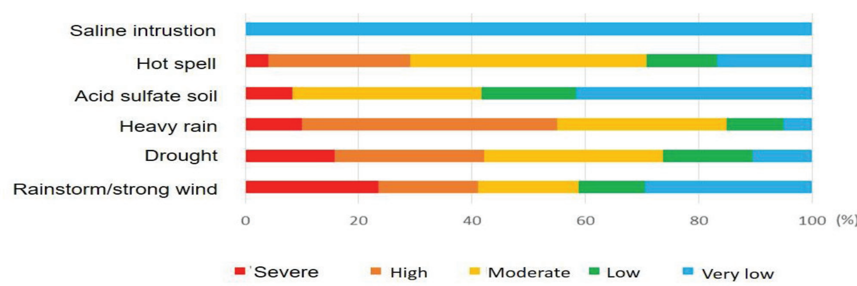


Fig. 7. Impact factors on agricultural production.

there is no suitable land use type in AEZ I (lowest area, the area which is the most heavily affected by salinization). However, using some adaptable solutions (using short-time varieties, storing freshwater), the double-rice crop is still chosen to cultivate. In AEZ II and AEZ III (medium and high areas, less affected by salinization), the double-rice crop pattern is also selected. The

Table 8. Participatory land use plan with CC-SLR adaptation.

LUs	Current land uses	PLUP suitability			Selected
		LUT 1 (Double-rice)	*LUT 2 (Triple-rice)*	*LUT 3 (Upland)*	
1a	Triple- rice crops	0	0	0	Double-rice crops (short-duration)
1b	Double-rice crops	0	0	0	Double-rice crops (short- duration)
2	Double-rice crops	2	0	2	Double-rice crops (short- duration)
3	Upland crops	1	0	2	Double-rice crops / Upland crop

Note: levels score - 0: not suitable; 1: marginally suitable; 2: moderately suitable; 3: highly suitable.

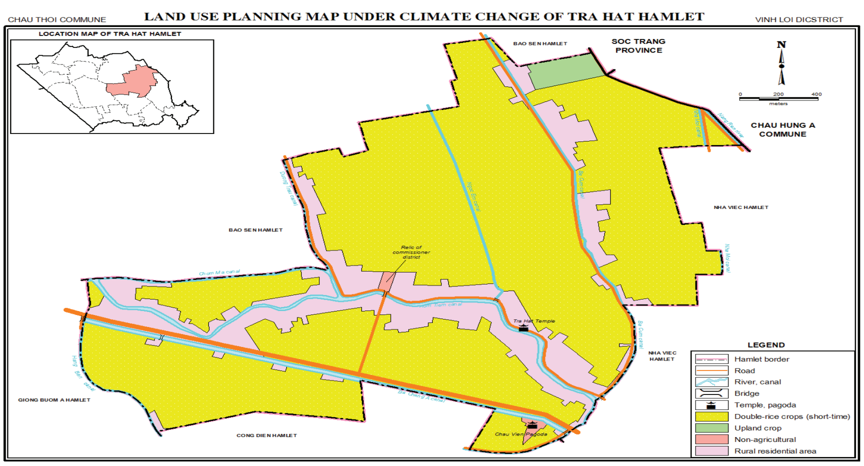


Fig. 8. Land use planning map in 2020 under the impacts of climate change and sea level rise of Tra Hat village.

upland crop pattern is chosen in AEZ IV. Especially, triple-rice crops are not suitable in all AEZs (Table 8, and Fig. 8).

Conclusions

Participatory data collection and mapping via group discussions with farmers revealed the detailed and highly accurate knowledge of local community members regarding natural and land use conditions. Local knowledge can contribute as an important early warning system to understand the resources distribution, ecosystem, and impacts of climate change and sea level rise and potentially provide a needed edge to a more effective management of production in the context of changes.

Differences on results of the PLUP with climate change-sea level rise adaptation compared with the PLUP without climate change adaptation demonstrated the identification and cognition ability of farmers prior to events of vulnerabilities and risks from climate change have considerable effects during and after the events and land use demands and agricultural production level which is suitable for market demands.

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