



Adaptation of Communes to Climate Change Impacts on Livelihoods in Lung Ngoc Hoang Natural Reserve, Phung Hiep District, Hau Giang province, Vietnam

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ABSTRACT: This study aims to investigate climate change impact on livelihoods of the community living within the surroundings of Lung Ngoc Hoang Natural Reserve, Hau Giang province, Vietnam. Three communes located in the buffer zone, administrative service zone, and ecological restoration zone, respectively were selected for the investigation. At each site, the managers and residents including both men and women, were invited to attend and discuss the resources use and daily livelihood activities. The participatory tools were used to assess the link between resource use and climate change impacts including resource ratings, resource distribution mapping, seasonal calendars, climate history and coping strategies used by the community. It was found that the livelihoods of people in the study areas were mainly rice-fish farming, growing fruit trees and participating in agricultural and non-agricultural hired labor. Local community also heavily rely on the natural resources provided by wetlands for income. In the past, the livelihoods of people in the adjacent areas were mainly affected by drought and floods and their coping ability was limited. Currently, rice and water are the two most important wetland resources. The residents are now experiencing the impacts of climate change, manifesting as poor water quality due to drought and floods, directly affecting quality of life. However, coping climate impact strategies of the community have not been very effective, and therefore must continue to explore other options, especially as climate impacts exacerbate the situation. Development of policies to support local people and increase investment in economic development to limit pressures on natural resources in the reserve is urgently needed.

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Lung Ngoc Hoang Nature (LNH) Natural Reserve (NR), Phung Hiep District, Hau Giang Province was established 2002. It is located on low-lying land, with typical topography of the area south of the Hau River. Lung Ngoc Hoang NR is located in the low-lying area of the West Hau River, between the two ecological regions of the West Hau River and the Ca Mau Peninsula. This area was formed during the sea recession and alluvial deposition, and consists mainly of coastal sediments and swamps, forming a low and fairly flat terrain, with an average elevation varying

from 0.30 m to 1.50 m (People's Committee of Hau Giang province, 2016). In the region, there is an open canal system through low-lying areas, connecting Lung Ngoc Hoang NR with adjacent areas such as Lai Hieu canal and Hau Giang 3 canal. The system connects with Cai Lon and Cai Tau Rivers, which drain to the West Sea (Gulf of Thailand); and Sang Bo canal, Chu Ba and Xeo Xu canals emptying into Quan Lo - Phung Hiep canal, connecting with the East Sea and the Ca Mau peninsula. Due to the interlaced canal system and geographic location, the hydrological

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regime is influenced by the intra-provincial rainfall regime, the flood zone of the Hau River and the high tides of the East Sea and the West Sea (Gulf of Thailand) (Hoa, 2015). Wetland habitats in Lung Ngoc Hoang NR can be divided into four categories including melaleuca forest habitat, shallow wetland forest habitat, open water habitat and agricultural habitat (Giao et al., 2022). In Lung Ngoc Hoang Nature Reserve, 352 species of higher vascular plants belonging to 257 genera of 94 families have been recorded. The reserve is the place for at least 59 species of annelids and arthropods, 13 species of mollusks, 20 species of benthic animals, 78 species of blue-green algae and 95 species of green algae and 75 species of fish (Dan, 2018). Among the plant and animal species found in the nature reserve, there are 13 species listed in the Red Book of Vietnam and the World. Invasive alien species are a growing concern in the nature reserve. At least eight invasive alien species have been recorded in Lung Ngoc Hoang, including *Pterygoplichthys disjunctivus*, *Clarias gariepinus*, *Pomacea canaliculata*, *Eichhornia crassipes*, *Eupatorium odoratum*, *Lantana camara*, *Callisi fragrans*, *Imperata cylindrica* (Ni, 2018): Lung Ngoc Hoang Nature Reserve was formed from the Phuong Ninh State Farm, which grew rice and produced agriculture to meet the food needs of the province (People's Committee of Hau Giang province, 2011). Due to historical factors of the formation of special-use forests, there are many residential clusters and households living and working in the nature reserve buffer zone, and there is ongoing agricultural production within the NR. There are about 1,057.91 hectares of forest land used by households for agricultural cultivation. The main crops are rice, pineapple, banana, aquaculture and livestock and poultry farming. In 2019, there were six households using contracted land for rice cultivation, who also dug fish ponds covering an area of 4.86 ha, to raise snakeskin gourami (*Trichogaster pectoralis*) and tilapia (*Oreochromis mossambicus*) (Du, 2018). In addition, the study area is flooded for six months of the year, with the water in rivers about 0.5-1.5 meters higher than in dry season, creating favorable conditions to develop ecological aquaculture production. The relatively low incomes of community members lead to difficulties in access to transportation, clean water, environmental sanitation and a rural health network (People's Committee of Hau Giang province, 2016).

The Mekong Delta is one of the three deltas in the world most vulnerable to climate change and sea level rise. It is forecasted that by 2030, about 45% of the Mekong Delta will face the risk of salinization due to sea level rise (MONRE, 2016). According to the latest

scenarios on climate change and sea level rise, if the sea level rises by 100 cm by 2100, up to 38.9% of the Mekong Delta's land area will be flooded, and 35% of the population will be directly affected. The provinces with the highest risk of flooding are Hau Giang (80.62% area will be flooded), Kien Giang (76.86%) and Ca Mau (57.69%) (MONRE, 2016). Specifically, in Long My district (97.97%) and Phung Hiep district (92.94%), Hau Giang, are the two districts at highest risk of flooding (MONRE, 2016; Ni, 2018). Salt water has contaminated the Cai Lon River through Kien Giang province and has penetrated as far as Hau Giang. When drought occurs, nearly the entire area of Hau Giang province is affected by salinity intrusion and the salt is retained for a long time in the low-lying areas of Phung Hiep and Long My, greatly impacting local livelihoods (Du, 2018; Ni, 2018). In the Nature Reserve, climate-related threats include prolonged heat, erratic rain and sea level rise. Specifically, prolonged hot weather increases the risk of forest fires, especially in melaleuca areas. Rainfall is expected to increase and become more erratic, this can lead to huge fluctuations in the amount of water available in the soil and also lead to the decomposition of organic matter, impacting on fisheries (Hung, 2013; Du, 2018; Ni, 2018; Giao et al., 2022). Lung Ngoc Hoang Nature Reserve has the lowest elevation in Phung Hiep district, which is considered as one of the two districts most likely to flood as a result of sea level rise. To the best of our knowledge, information on climate change impact on livelihoods of community and adaptation to the impact is currently limited. This study investigates impact of climate changes on livelihoods of local community living around Lung Ngoc Hoang Reserve in Phung Hiep district, Hau Giang province, Vietnam and recommends current and future adaptation strategies.

MATERIALS AND METHODS

Site description: Lung Ngoc Hoang Nature Reserve was established on the land of the Phuong Ninh Forest Enterprise. It is located in Phung Hiep district, formerly Can Tho province, which is now in Phuong Binh commune, Phung Hiep district, Hau Giang Figure 1. Due to the influence of previous forest planning processes, there are still many residential clusters and households located within the NR and the surrounding buffer zone. The total number of households living inside Lung Ngoc Hoang Nature Reserve by the end of 2019 was 947 households with 2,637 people. In which, there are 545 households inside the dike and 402 households outside the dike. Population in strictly Protected Zone are 120 households, these are households that need to be relocated; in ecological Restoration Zone are 190 households; and in the administrative Service Zone are

637 households. Currently, there are 14 policy households in the NR (households with members who are wounded or sick soldiers, or someone with who has served the country); 42 poor households (households whose per capita income is less than 700,000 VND in rural areas); 31 near-poor households (households that have per capita income over 700,000 - 1,000,000 VND (rural) 900,000 - 1,300,000 VND and lack basic social services); and 8 ethnic minority households, whose average incomes have not been studied. Among the households that are involved in agricultural cultivation in the NR, there were 873 contracted households in 2020, but only 357 households have signed production

contracts for rice and sugarcane, the remaining households have not signed contracts with the NR. The reason is that according to the 2013 Land Law, there is no longer a form of contracting agricultural land; therefore, the management board has not signed any contracts since 2015. However, these households are still able to cultivate agriculture and harvest products. The national defense and security situation in the area is relatively stable. However, due to the history of the site, the households living in the NR have not yet been granted a certificate of land use rights, although they have been residing in the area for a long time. Some households have ongoing disputes with the NR.

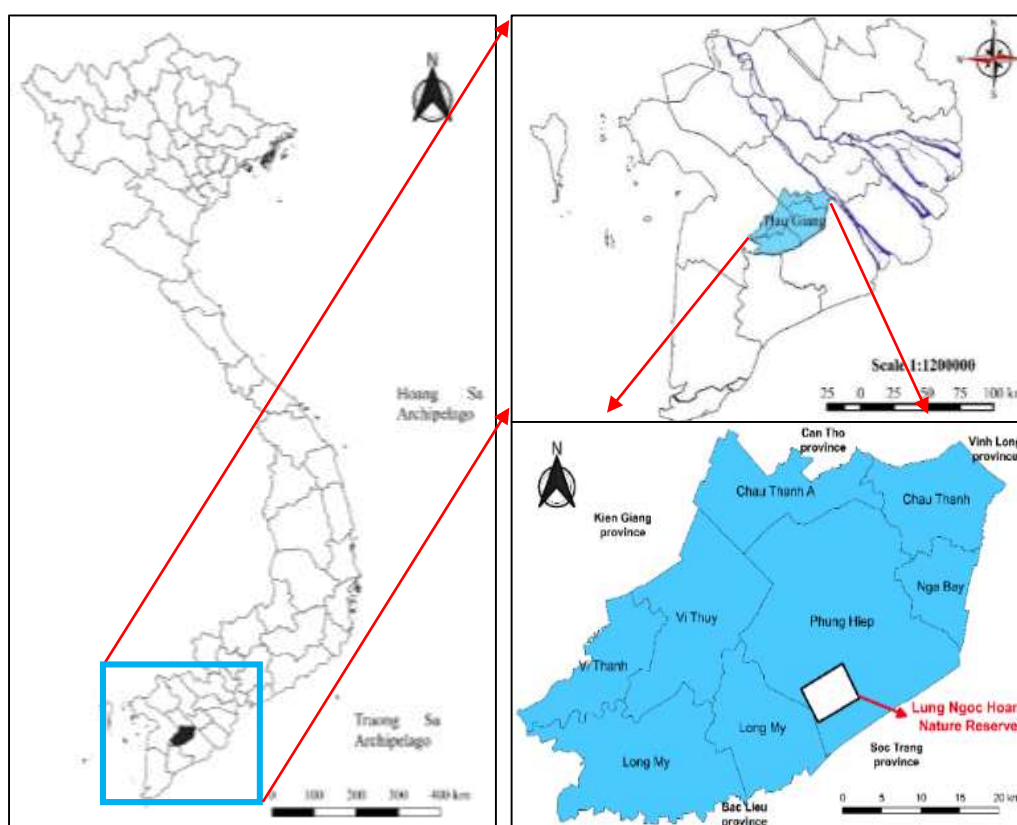


Fig 1. Location map of Lung Ngoc Hoang Nature Reserve, Viet Nam

Furthermore, according to the report of People's Committee of Phung Hiep District (2019), there is no significant difference in the male/female ratio in the communes, which range from 50.8 - 51.8% (male) and 48.2 - 49.1% (female). According to a report by Du (2018), men are more directly involved in farming than women. Information on gender-related roles and responsibilities in the production and sale of food and other natural resources in the area is very limited. There are few people with education levels above secondary school in Lung Ngoc Hoang NR, with many residents who are illiterate and/or have only completed primary school, which is especially true for women

(Du, 2018). The average level of education is very low, which may make it difficult for them to access information on climate change and strategies to cope with the impacts of climate change (Du, 2018; Ni, 2018; Dan, 2018).

Data collection: The assessment team selected five areas in three communes around the NR to assess the vulnerability to climate change (Figure 2). Three hamlets belong to Phung Binh commune, one hamlet belongs to Phung Phu commune and one hamlet belongs to Hiep Hung commune. The hamlets of Long Phung A, Phung Hoa, Phung Lac and Phung Quoi

A were chosen because of their dependence on the resources of the nature reserve. These hamlets are located in the buffer zone, Administrative Service Zone, and Ecological Restoration Zone, respectively. Meanwhile, Binh Hoa hamlet (Phuong Phu commune) was chosen because it is an area where 120 households still cultivate in the Strictly Protected Area of the Nature Reserve. At each site, the team worked with community members in the area to complete a

Participatory Rapid Appraisal (PRA). Managers and residents, including both men and women, were invited to attend and discuss the resources they use and their daily livelihood activities. The participatory tools used to assess the link between resource use and climate change impacts include: resource ratings, resource distribution mapping, seasonal calendars, climate history and coping strategies used by the community.

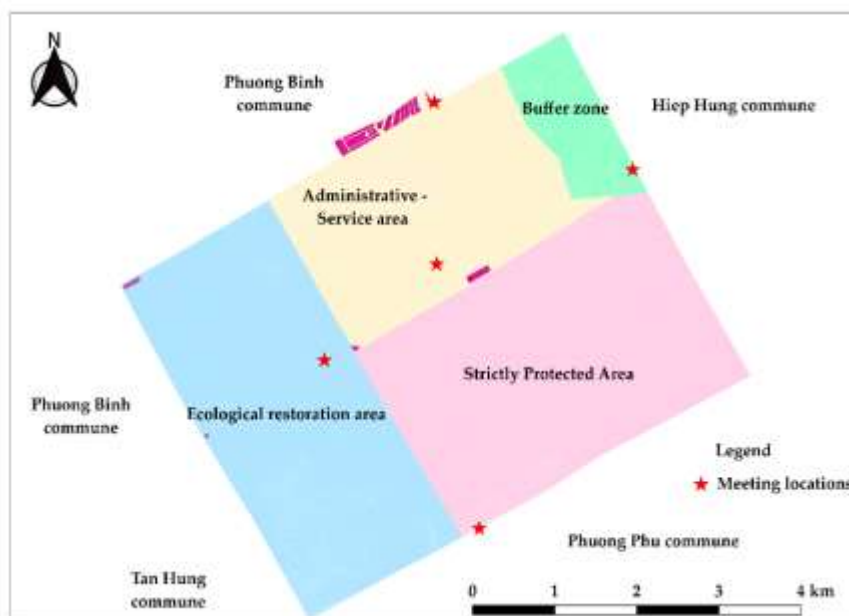


Fig 21. Location of meeting points at Lung Ngoc Hoang Nature Reserve

RESULTS AND DISCUSSIONS

Dependence on wetland resources of the community:
In Phuong Lac hamlet, local people use 12-13 main wetland resources, while in Binh Hoa hamlet, participants only mentioned seven main resources. This can be explained by the geographical location of each hamlet, and the quality of life of the people. Specifically, Long Phung A and Phuong Hoa hamlets are located in the buffer zone; Phuong Lac and Phuong Quoi A hamlets are located in the administrative-service area and ecological restoration area, respectively; therefore, the dependency on the resources varies. In Binh Hoa hamlet, the people's quality of life is assessed as better than in other study locations. The overall pattern of wetland resource use is quite similar, however, there are some differences between hamlets. Rice, fruit trees and water are the main resources for people, and other resources such as bananas, fish, vegetables, fruit trees, forest vegetables, pineapple, medicinal materials, lotus and honey are also important. Water is mainly used for domestic purposes (bathing, washing and dishwashing) and irrigation. People in Phuong Hoa hamlet, Phuong Lac

hamlet, Long Phung A hamlet mainly cultivate rice. Pineapple is also a main resource of the people of Phuong Lac hamlet. Residents of Binh Hoa hamlet mainly grow fruit trees, including Taiwanese mango, Thai jackfruit, coconut and milk fruit. Phuong Quoi A hamlet is located within the ecological restoration area and is allocated forest land in the NR to support their livelihoods and the community works together with the NR management board to protect the forest. Therefore, people in this hamlet frequently access and depend on the nature reserve.

Table 1, Table 2 and Table 3 presented the seasonal schedule of the use and harvesting of wetland resources. This provides more detail on resource use and extraction throughout the year, along with changes in key weather conditions. In all hamlets, river water extraction is carried out all year round; however, the exploitation of river water is limited from April to May and September to October, because the NR opens the dams to exchange water within canals during this time. Therefore, the water quality in rivers and canals is affected by pollutants from the Melaleuca Forest and

becomes unusable. Well water is also used by people year-round, and is also limited in the dry months. Locals believe that during the dry months, the water quality is reduced due to the acid sulfate in the area's soil, therefore, in the dry season the water source is contaminated with acid sulfate soil and has a bad smell. This leads to water shortages in the dry season. Residents often practice rainwater collection from June to October, utilizing this water to ensure clean and safe water sources. People in Long Phung A hamlet, Phuong Hoa hamlet and Phuong Lac hamlet mainly cultivate two crops (winter-spring and summer-autumn). From July to November, rice cultivation activities are restricted due to the floods, therefore, people instead raised fish, beginning after the end of the summer-autumn crop and harvesting them before the start of the winter-spring crop.

Pineapple planting in Phuong Lac hamlet is done all year round, growing them for 18 months, and harvesting twice a year. Beekeeping in Phuong Quoi

A commune is carried out from early November, at the end of the rainy season, until March, then it is harvested before the next rainy season starts (Table 2). Honey collection depends on the weather; therefore, it is only done once a year.

Using this approach, people in Phuong Quoi A hamlet have diversified their income sources by doing agricultural and non-agricultural jobs all year round. Most other activities in the hamlets are carried out all year round. Bananas are grown for 7-8 months, and can be harvested, about 3 times/month, however they are harvested the most from January to February. Fruit in Binh Hoa hamlet is grown all year round, with mango harvested twice a year (February to March and September to October), and custard apple harvested between March and April. In general, the cultivation of rice and fish is seasonal, and the cultivation of fruit trees and the exploitation of other resources (bananas, lotus, forest vegetables, agricultural and non-agricultural labor) takes place throughout the year.

Table 1. Resource use history and livelihood activities of (a) Phuong Hoa hamlet, (b) Phuong Lac hamlet and (c) Phuong Quoi hamlet A

(a) Phuong Hoa Hamlet (buffer zone)												
Activity	1	2	3	4	5	6	7	8	9	10	11	12
Use of river water												
Use of well water												
Rice cultivation	Crop 1				Crop 2							
Banana planting	Harvest											
Fish farming												
Use of rain water												
Fruit tree planting				Harvest								
Forest vegetable collect												
Medicinal plant collects												
Laboring												

(b) Phuong Lac Hamlet (Administrative Service Area)												
Activity	1	2	3	4	5	6	7	8	9	10	11	12
Use of river water												
Use of well water												
Rice cultivation	Crop 1				Crop 2							Crop 1
Banana planting												
Pineapple planting												
Fish farming												
Use of rain water												
Fruit tree planting												
Forest vegetable collect												
Medicinal plant planting												
Lotus planting												

(c) Phuong Quoi A Hamlet (Ecological Restoration Area)												
Activity	1	2	3	4	5	6	7	8	9	10	11	12
Use of river water												
Use of well water												
Use of rainwater												
Honey collection												
Banana planting												
Wild fish exploitation												
Fruit tree planting												
Forest vegetable collect												
Lotus planting												
Laboring												

Notes: Months are highlighted in bold; as the most harvest time of the year.

Table 2. History of resource use and livelihood activities of Long Phung A hamlet

Activity	1	2	3	4	5	6	7	8	9	10	11	12
Use of river water												
Use of well water												
Rice cultivation		Crop 1			Crop 2						Crop 1	
Mango planting												
Snail growing												
Carp farming												
Use of rainwater												
Banana planting												
Planting/Exploiting water lily												

Table 3. History of resource use and livelihood activities of Binh Hoa hamlet

Activity	1	2	3	4	5	6	7	8	9	10	11	12
Use of river water												
Use of well water												
Mango planting			Harvest						Harvest			
Snail growing												
<i>Cyprinus carpio</i> , <i>Hypophthalmichthys</i> growing												
Use of rainwater												
Banana planting												
Planting/Exploiting water lily												
Melaleuca planting												
Milk fruit planting				Harvest								
Coconut planting												
Orange planting												
Jackfruit planting												

Table 4. History of extreme weather events and impacts

Extreme event	Year	Impacts
Heat and drought	2021 – Phuong Hoa hamlet, Phuong Lac hamlet, Phuong Quoi A hamlet and Long Phung A hamlet	Increased illness; people's livelihoods are affected, crop loss/low rice yield; lack of water and poor quality of groundwater; polluted river water; reduced quality of life.
Strong wind	2018 – Phuong Quoi A hamlet 2020 – Phuong Quoi A hamlet, Phuong Lac hamlet and Phuong Hoa hamlet and Binh Hoa hamlet	Falling trees, storms destroy homes; livestock died; directly affects people's income.
Flooding and Prolonged rain	2017 – Long Phung A hamlet and Phuong Lac hamlet 2019 – Phuong Quoi A hamlet 2020 - Phuong Quoi A hamlet, Phuong Lac hamlet and Phuong Hoa hamlet, Long Phung A hamlet and Binh Hoa hamlet 2021 – Phuong Lac Hamlet	Crops and Melaleuca died due to waterlogging; damage to houses due to water damage to some household items; navigation is difficult; reduced water quality due to water accumulation and decomposition from the Melaleuca area; aquatic resources are lost due to rising water levels.
Saline intrusion	2016 – Phuong Lac hamlet and Phuong Quoi hamlet A	Some crops were damaged (sugarcane, cucumber); some natural food sources lost (water lily); rice fields withered and died; soil quality degraded.

Impact of climate change on livelihoods of the community: To better understand how climate change affects local communities, participants were asked to recall extreme weather events and impacts over a 10-year period. The main types of extreme events and their impacts on people's livelihoods, wetland habitats and important species are summarized in Table 4. Five extreme weather events that people consider to have significant impacts in the region are high temperature, prolonged rain, strong wind, floods and saltwater

intrusion. High temperature is identified as an annual phenomenon that significantly affects rice yield and causes poor water quality and water shortage. Other weather events such as prolonged rain accompanied by floods have occurred more frequently in recent years, with varying impacts. Local people think that prolonged rain, leading to flooding is the event that has caused the most damage. Participants recalled a flood in 2017 which did not cause much damage, and only impacted two areas of Phuong Lac and Long Phung A

hamlets. The 2020 flood season led to much greater damage from flooding, causing a die-off of plants, particularly impacting rice cultivation areas. Melaleuca trees also died due to waterlogging, which was mentioned as a concerning problem because it has never before occurred, and there are no preventive measures. The simultaneous impact of rain and flooding has increased inundation, which has reduced soil quality in some habitats, especially agricultural habitats. Flooding impacts local livelihoods, causes infrastructure damage, and leads to navigation difficulties. Floods also cause the water levels to rise, leading to loss of aquatic resources in Long Phung A hamlet and Phuong Hoa hamlet. In addition, water quality in the Melaleuca habitat was severely reduced due to water accumulation and decomposition of fallen objects (Giao *et al.*, 2022).

In 2016, Phuong Lac and Phuong Quoi A hamlets were affected by saline intrusion. Some farmers did not detect it in time, so they pumped the saline water into the fields to irrigate, leading to the death of their rice and vegetable crops; . There was no warning about the drought and saline intrusion during that time, which may have prevented the loss of the crops; however, there are warning systems in place now to warn people earlier about saltwater intrusion . The salinity levels were mild and the drought only persisted for ten days, limiting further impacts. Local people began to notice occasions of extreme heat and drought around 2016. By 2021, most residences within the study area were significantly affected by extreme heat events. Increased heat results in farmers spending more money on irrigation. Heat also affects laborers who are unable to do their jobs during normal working hours. The increased temperatures and drought activate the acid sulfate soil because acid sulfate soils have the ability to release many acids and heavy metals in dry conditions (Kawahigashi *et al.*, 2008), affecting some crop areas in Phuong Lac and Phuong Hoa hamlets and Long Phung A. Groundwater quality in the area is also reduced due to heavy acid sulfate soil contamination, and there is a lack of water for domestic use and farming. Poor water quality as a result of drought leads to reductions in crop yields and an increase of diseases, such as diarrhea, which tends to impact children the most. The river water is also polluted as it receives most of the household and agricultural wastewater from the area and is not amply diluted by other water sources. Despite this, river water is still used in households because there is limited access to alternative clean water sources. Residents also reported strong wind and storms in 2018 and 2020, which damaged many houses, fruit trees and led to the death of some livestock, directly affecting local incomes. In general, phenomena related

to climate change are believed to have greater impacts on livelihoods than on habitats and species in the area. Hot weather and floods are two phenomena that have severely affected people and habitats in the recent past.

Current and future coping strategies with climate change of the community: The women and men from each hamlet were divided into two separate groups to explain how they cope with current and future climate change extremes. In coping with the effects of climate change, there are almost no significant differences between men and women, and existing coping strategies are perceived as only partially mitigating the impacts and could be improved. For impacts such as damage to crops, people are mainly planting new crops or converting to other crops with higher economic efficiency, such as salt-tolerant varieties or crops more suitable for soil conditions in the area. In the case of water shortages and poor groundwater quality or river water pollution due to drought and flood, both men and women use other water sources or continue to use the polluted water, after processing it first. Specifically, they use rainwater rather than river water in the rainy months, and rainwater is stored for use in the dry season, to reduce the pressure on contaminated well water. In Phuong Hoa hamlet, residents reported climate change events including heat, strong wind, rain and floods (Table 4). In the face of hot weather, men often try to minimize the impact by pumping more water into rice fields and using more fertilizer for plants, but this can have a negative impact on resources and ecosystems. In case of floods, they often harvest rice early and prevent the escape of farmed fish by reinforcing the embankment or using nets to prevent loss. Meanwhile, women have almost no strategy to deal with the loss of crops and plan to plant new crops in the next cycle. In the dry season, the water quality is relatively poor, and households boil the water before using. If the water quality is still not suitable, communities will try to drill a new well, however, when they were asked how to better cope with the water situation, people mainly rely on receiving support from the locality. In addition, there are a number of measures that people in the hamlets have used when addressing the impacts of flooding, such as reinforcing houses, using boats to move around and building high dikes. Similar strategies were also used in Phuong Lac hamlet, however, there are also some differences because Phuong Lac is also affected by saline intrusion, which is often unpredictable. When affected, most people have no suitable countermeasures, however farmers have begun to convert crops to more salt-tolerant species, for example, by replacing rice with durian, and sugarcane with pineapple. The area has also been built sluices, dams and embankments to control salinity. In

the future, people will monitor local announcements, in order to understand when saltwater is a risk. When locals are aware of high salinity, they refrain from irrigating their crops. In Phuong Quoi A hamlet, Long Phung A hamlet and Binh Hoa hamlet, climate change impacts are less severe than in Phuong Hoa and Phuong Lac hamlets. However, similar measures are also taken, including replanting trees, building high dikes and reinforcing houses. In Binh Hoa hamlet,

residents reported that the weather has not significantly affected livelihood activities. There are still strong winds during the year but because the hamlet is located in the core zone, the wind is not strong enough to affect people. As a result, most residents do not have any recommendations for future coping strategies. Current and future management strategies in the hamlets are detailed in Tables 4-8.

Table 4. Impact of extreme events and current coping strategies in Phuong Hoa hamlet

Event	Impact	Current coping strategies		Future coping strategies	
		Male	Female	Male	Female
Heat	Livelihoods affected		Diversify income and save	No coping strategy	No coping strategy
	Disease	Temporary medicine and going to the hospital	Buy medicine and use herbs available in the garden	Buy medicine, if it's severe, go to the hospital	
	Yield loss	Pumping water for the farming area, using a lot of fertilizer for plants	Replant new crops	Do not convert crops, produce without fertilizer to avoid much damage, cut down diseased trees; prepare the pump	No coping strategy; waiting for new planting in the next crop
	Water shortage	Store rain water in proper containers in the rainy season, use treated river water	Use alternative water sources	Pumping water from canals, ditches, ponds, wells, storing rain water	Have a policy to bring clean water into the locality
	Low groundwater quality	Use alum and cook before use; drill again if the water quality is too poor (too much alum and bad smell)	Use alum before use, alternating with available water sources (rainwater)	Request support for local clean water policies	Request support for local clean water policies
	Low surface water quality	No coping strategy	No coping strategy	Borrow money from the bank	No coping strategy
	Canal water polluted	No coping strategy	No coping strategy	No coping strategy	No coping strategy
Strong wind	Fallen trees	Replant the trees	Replant the trees	Replant the trees	Replant the trees
	House damaged	Build a solid house	Reinforce the houses, get support from the locality	Build a solid house	Build a solid house, establish the green belt for protection
Rain and flooding	House damaged	Reinforce the houses	Lift the household items	Build a solid house, build on a high foundation	Build a solid house and have a large wind barrier (if possible)
	Fish and tree loss	Use nets to prevent loss, embankment to avoid flooding; early harvest	No coping strategy	No coping strategy	No coping strategy
	Difficulty in transport	Use boats to move, build dikes to limit the harm	Use boats to move	Use boats to move	Use boats to move

Table 5. Impact of extreme events and current coping strategies in Phuong Lac hamlet

Event	Impact	Current coping strategies		Future coping strategies	
		Male	Female	Male	Female
Heat	Groundwater quality declines	Using alternative water sources: retaining rainwater with palanquin pots; eater for drinking will be cooked, domestic water will be treated using alum; some households invest in more large tanks and use more water purifiers	Storage by containers, use alum to settle down the contaminants	There is no other response strategy. Waiting for clean water from the support of the government	No coping strategy
	Disease	Apply medicine and transfer to the hospital	Use available plant medicine, go to hospital.	Go to the hospital, take medicine	Use available plant medicine, go to hospital
	Livelihood	NA	Rearrange work time (Take advantage of early work to avoid hot weather).	NA	NA
	River water polluted	Use water at certain times	Water treatment before use (alum for sedimentation, ...)	No coping strategy	No coping strategy
	Fish stock decline	No coping strategy	No coping strategy	No coping strategy	No coping strategy
Strong wind	House damaged	Reinforcing houses, using zinc and cables to fix, rebuilding houses	Reinforcing houses	Reinforcing houses	
	Fallen trees (especially large and tall trees)	Replant the trees	Replant the trees	Replant the trees	Replant the trees
Prolonged rain and flooding	House damaged	Place household items, Raise the floor higher than before	Moved away from residence (to Binh Duong), due to heavy damage; Lift household items		
	Plant death due to waterlogging (rice damage is about 50% in 2020)	Build high embankment, prepare embankment	Move out of residence (to Binh Duong)	Switch to another crop if it continues to be affected	Take advantage of early farming to avoid flooding; diversify income
	Unable to use roads to get around	Use the boat to move	Use boat to move, use wooden pieces to move around the house	Dredging canals, rivers.	Build embankment
	Reducing fish stocks due to rising water	Because it has never happened in the locality, there are no measures	NA	Build higher dikes, use nets to block	NA
Saline intrusion	Damage to crops (rice, sugarcane, cucumber)	Changing crops (rice to lemon durian, sugarcane to pineapple); Building sluices, dams and embankments to control saltwater.	Converting crops (sugarcane to pineapple)	When people know the saltwater, people stop putting water into the fields, build sluice gates.	
	Reduced soil quality	Improve the soil using fertilizer and plowing	Washing soil to reduce salinity		
	Natural food source is damaged	No coping strategy	No coping strategy		

Table 6. Impact of extreme events and current coping strategies in Phuong Quoi A

Event	Impact	Current coping strategies		Future coping strategies	
		Male	Female	Male	Female
Strong wind	Falling tree (banana)	Replant trees, crop conversion	Replanting	Replant trees, crop conversion	Replanting
	House damaged	House improvement, New construction	House improvement	No coping strategy	No coping strategy
Saline intrusion	Crop damaged	Crop conversion	Changing crops (planting mangoes), but not effective, not bringing high income	Plant salt-tolerant varieties	Varietal conversion
	Water quality decline	Store rainwater for use; Lime water treatment; Build a sluice to prevent saltwater	NA	Ask the government for help to prevent salt water from entering the canals.	NA
	Waterlogged cause tree death	Some households switched to planting and raising other livestock	Replanting	No coping strategy	No coping strategy
Rain and flooding	House damaged	Increase elevation above ground	House improvement	House reinforcement, media/news listening, and damage prevention methods	
	Aquatic resources decrease due to rising water levels	Increase elevation above ground, switch to using farmed fish and wait for natural fish to regenerate	There is no appropriate management policy	NA	NA

Table 7. Impact of extreme events and current coping strategies in Long Phung A

Event	Impact	Current coping strategies		Future coping strategies	
		Male	Female	Male	Female
Strong wind	Fallen trees	Replanting, crop conversion	Replanting	No coping strategy	No coping strategy
	House damaged	Reinforce the houses, new construction	Reinforce the houses	No coping strategy	No coping strategy
Heat	Rice yield decrease	No coping strategy	Pumping water into the field	Choose the drought tolerant species	Crop conversion
	Water quality decrease	Rainwater storage for use, river water treatment	Rainwater storage for use, river water treatment	NA	NA
Flooding	Reduced rice yield and bananas may die	Build higher dykes to prevent floods, plant rice sooner	Waiting for next season to cultivate	No coping strategy	No coping strategy
	Quality of life decrease	No coping strategy	No coping strategy	No coping strategy	No coping strategy
	Aquatic resources decrease	Build higher embankments	Use net to block the fish way	NA	NA

Table 8. Impact of extreme events and current coping strategies in Binh Hoa

Event	Impact	Current coping strategies		Future coping strategies	
		Male	Female	Male	Female
Strong wind	Fallen trees	Replanting, crop conversion	Replanting	No coping strategy	No coping strategy
	House damaged	Strengthening the house construction	Reinforce the house	No coping strategy	No coping strategy
Flooding	Water flooded trees	Some households switched to planting and raising other livestock	Replanting	No coping strategy	No coping strategy
	House damaged	Elevate the house	Reinforce the place		
	Fish stock decline	Higher the dykes, switch to using farmed fish and wait for natural fish to regenerate	There is no appropriate management policy	NA	NA

Table 9. Current and future wetland management strategies of key resources

Natural resources	Purposes of use	Current management	Future management
Rice	Sell, food	Planned for two-rice crop cultivation and intercropping with fish to avoid damage to crops/livestock at the time of flood/salt intrusion. The dyke/slucice facilitates irrigation and prevents silt in the field.	Provide information on floods and water quality to promptly regulate water. Farmers can also convert rice to other crops.
Rain water	Domestic activity	There is no management policy in any area.	Need help building containers to collect and store rain water.
Well water	Domestic activity	There is support for people to drill concentrated wells. Since well water is highly acidic and polluted, some drill and but do not use water from the areas of Phuong Binh and Hiep Hung communes.	Need state support to build a clean water supply system for Phuong Binh commune. Drill wells with a depth of more than 120 m to get groundwater. Treatment of alkaline water for households (Phuong Binh and Hiep Hung communes).
River water	Cultivation, domestic use	Ban on discharging wastewater into the river; invested in sewer systems to prevent salinity and control water. The management regularly removes invasive species.	Need help to manage water quality from NR and provide information on flood status/hydrology and salinity intrusion.
Banana	Food, feed, sell	Removal of old and diseased or unharvested plants twice a year.	Maintain current management policies
Farmed fish	Sell, Food	There is no management policy	Measures should be taken to avoid fish loss during the farming process (Phuong Binh and Hiep Hung communes). Taller dams can be built to keep fish in ponds during floods.
Wild vegetables	Sell, food	There is no management policy	No management policy needed
Fruit trees	Sell, food	Trees have not yet been affected, therefore there is no specific management policy (Phuong Binh commune). There are measures to prevent pests (Binh Hoa hamlet); The crops are highly competitive in the market (low prices) but yield is not stable. People do not have knowledge about the crops they are producing, they are also very dependent on the weather in all areas.	There is no future management policy
Forest vegetables	Food	There is no management policy	It is possible to grow short-term vegetables suitable for the inundation regime in the forest.
Field fish	Food	Demarcate permitted fishing areas.	There is a management plan for the period 2021 – 2030 for the conservation area: (1) patrolling and stopping activities that violate the forest law; (2) prohibiting fishing during the breeding season in the NR; (3) clearing vegetation in the areas where fish spawn; (4) training and identification of rare freshwater fish species and their reproductive behavior; (5) clearing canals and increasing water exchange between areas inside and outside the NR
Pineapple	Sell, Food	There is planning for a pineapple growing area	No need for changes to future management
Medicinal plants	Health and medication	There is no management policy	To set aside a natural area (3 hectares) to grow medicinal plants in the Ecological Restoration Area (Phuong Binh commune) (2021 - 2025).
Lotus	Sell, food	Contracting land for cultivation and conservation	Use lotus growing areas for ecotourism visits.
Honey	Sell	Allocate the land area allowed to exploit and use honey in the ecological restoration area (Phuong Binh commune). There is no management policy for the remaining areas	Lung Ngoc Hoang Nature Reserve completed the plan for protecting beehives from 2020 - 2022. Specifically, the main implementation solutions are: (1) training on forest management and protection, sustainable honey extraction techniques; (2) monitoring the management and protection of forests for contracted individuals and forbidding the use fire to exploit honey.
Snail	Sell, food, feed	There is no management policy	There is no management policy

Recommending natural based-adaptation to climate change: After discussing strategies to cope with the impacts of climate change, participants discussed strategies to more effectively manage key wetland resources. Current management issues focus mainly on the management of water, rice, fruit trees and aquatic resources. Water resources are mainly managed by the state, especially river water. Policies on investment in a sewer system, regular removal of invasive alien species are locally managed and implemented. Groundwater has not been regulated, there is no regional planning, set exploitation depth, or existing treatment measures for non-exploited wells, and there are currently no effective water treatment measures.

The management board of the NR has supported communities in drilling wells, however due to concentrated acid sulfate soil, groundwater use is still limited. Therefore, the management of water resources in wetland areas remains difficult in the present and in the future. Rainwater is considered clean and safe, but there currently is no management policy on rainwater collection. In the future, the government should promote rainwater collection as a primary water source to avoid risks from groundwater contaminated with acid sulfate from the soil. Agriculture is the main livelihood of many residents in the Nature Reserve. Rice farmers generally cultivate two crops and intercrop them with fish. During the discussions, participants voiced a need for support on sharing information on floods and salinization to reduce crop and aquaculture losses. Fruit trees in Binh Hoa hamlet are only planted and not fertilised, watered or pruned, and there is no management policy for these. Fruit trees have not been seriously affected by climate change, so optimal management policies under climate change have not been recorded. The current crops are highly competitive in the market, yielding a low price, however, the yield is not stable. People do not have knowledge about the crops they are producing, they are also very dependent on the weather in all areas. Banana trees in the reserve are also cared for by the nature reserve. This policy is said to be effective in terms of productivity and income for the Management Board to support other activities in the reserve, therefore the reserve will continue this in the future. Local people also plant bananas to support their livelihoods. Lotus is managed by the Management Board of the Reserve under strict regulations in which they contract land to residents for cultivation in parallel with forest conservation. The land for honey collection is also contracted to residents in Phuong Quoi A hamlet, and there is no management policy for the remaining hamlets. Honey collection is regulated under the NR Management Board's plan to protect

beehives from 2020–2022. Fisheries areas are clearly divided into areas where fishing is permitted and conservation areas. Future management plans have also been proposed by the Management Board of Nature Reserve. The specific management strategies are presented in Table 9. In general, the management of groundwater and river water resources, as well as water from melaleuca habitats, needs immediate attention. Access to safe water is essential for supporting local communities and their livelihoods, and there is a need to build a clean water supply system for Phuong Hoa, Phuong Lac, Phuong Quoi A and Long Phung A hamlets.

Conclusions: Under the conditions of climate change, saltwater intrusion and permanent inundation due to sea level rise could pose a serious threat to community in Lung Ngoc Hoang Nature Reserve. The livelihoods of people in the area are mainly rice-fish farming (two rice crops and one fish crop), growing fruit trees and participating in agricultural and non-agricultural hired labor. However, local people also rely on the natural resources provided by wetlands for income and subsistence (Phuong Quoi A hamlet). In the past, the livelihoods of people in the adjacent areas were mainly affected by drought and floods and their coping ability was limited. Currently, rice and water are the two most important wetland resources. According to residents, they are already experiencing the impacts of climate change, manifesting as poor water quality due to drought and floods, directly affecting quality of life. They have developed some coping strategies, which have not been very effective, and therefore must continue to explore other options, especially as climate impacts exacerbate the situation. There is a direct link between local people's vulnerability and ecological vulnerability in Lung Ngoc Hoang Nature Reserve. Development of policies to support local people and increase investment in economic development to limit pressures on resources from Lung Ngoc Hoang NR. In addition, diversifying crops in agricultural habitats to increase resilience and reduce damage and loss to the impacts of climate change. According to the opinions of local officials and experts, it is urgent to promote regionally appropriate livelihood models.

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