FRIEDRICH EBERT STIFTUNG

# THE TRANSFORMATION OF SOUTHERN MEDIUM-SIZED CITIES TOWARD CLIMATE CHANGE RESILIENCE

## The cases of Ben Tre and Binh Duong provinces

NHÀ XUẤT BẢN THÔNG TIN VÀ TRUYỀN THÔNG
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| | |
|---|---|
| AFD | French Development Agency (Agence Française de Développement) |
| ASEAN | The Association of Southeast Asian Nations |
| BRT | Bus rapid transit |
| BD | Binh Duong Province |
| BT | Ben Tre Province |
| CDM | Clean Development Mechanism |
| CIDA | The Canadian International Development Agency |
| CNG | Compressed natural gas fuel |
| CRS | Congressional Research Service |
| DEA | The Danish Energy Agency |
| DFAT | The Department of Foreign Affairs and Trade, Australia |
| DFID | The Department for International Development |
| DONRE | Provincial Department of Natural Resources & Environment, Vietnam |
| EVN | Vietnam Electricity |
| EVs | Electric vehicles |
| FES | Friedrich-Ebert-Stiftung |
| GDP | Annual gross domestic product |
| GIZ | German Agency for International Cooperation GmbH |
| GHG | Greenhouse Gas |
| GRDP | Gross Regional Domestic Product |
| ILO | International Labour Organization |
| IPCC | Intergovernmental Panel on Climate Change |
| JICA | Japan International Cooperation Agency |
| K-EXIM | Korea Eximbank |
| MDP | Mekong Delta Plan |
| MOIT | The Ministry of Industry and Trade, Vietnam |

| | |
|---|---|
| MONRE | The Ministry of Natural Resources & Environment, Vietnam |
| NAP | National Action Plan |
| NCCC | The National Committee on Climate Change |
| NDC | Nationally Determined Contribution |
| NDCs | The Paris Agreement through Nationally Determined Contributions |
| PCCCO | The Climate Change Coordinating Office |
| PSCCC | The Provincial Steering Committee on Climate Change |
| RCP | Representative Concentration Pathway |
| SCCC | The National Steering Committee on Climate Change |
| SEI | SEI Asia - Stockholm Environment Institute |
| SPRCC | Support Program to Respond to Climate Change |
| UBND | The provincial People's Committee, Vietnam |
| UN | The United Nations |
| UN-Habitat | The United Nations Human Settlements Programme |
| USGCRP | U.S. Global Change Research Program |
| VGGS | The Vietnam Green Growth Strategy |
| VND | Vietnam Dong |
| WB | World Bank |

# I. INTRODUCTION

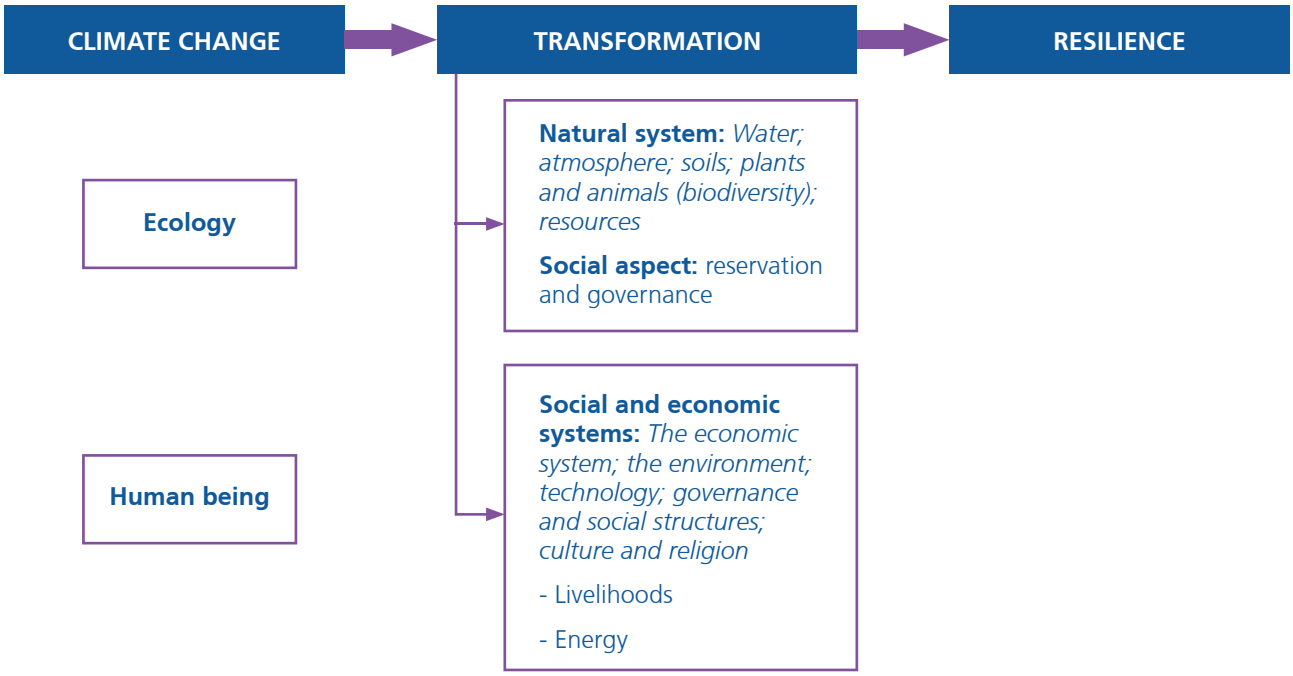
This paper tells the stories of people in two provinces: Ben Tre and Binh Duong. It describes how their livelihoods have been transformed thanks to government policies as well as their own initiatives and the effectiveness of these livelihood-changing strategies. The paper is based on a more rigorous research project funded by the Friedrich-Ebert-Stiftung (FES). Meanwhile, the outcomes are based on document analysis and interviews with farmers, government officials, and enterprises.

Concerns about environmental issues, including climate change, have been discussed for a long time along with the development of cities. However, it was not until the late 1970s that "climate change" officially became a global intergovernmental political issue. In this period, "greenhouse gas emissions" emerged as a scientific and political issue. Since then, climate change has gradually received greater attention from international experts and has been seen as a threat to global sustainable development. This attention to climate change comes from the evidence that human activities have caused greenhouse gas emissions leading to climate change which, in turn, results in extreme weather events or changes in natural conditions such as rising sea levels, higher temperatures, drought, and melting ice caps. Countries are starting to design strategies to simultaneously mitigate anthropogenic climate impacts and increase resilience to climate change.

Vietnam is considered to be one of the countries most vulnerable to climate change. As such, transformations to increase climate change resilience have officially started at the policy level. Meanwhile, Vietnamese people are also transforming their livelihoods and lifestyles to become more resilient and adapted to climatic changes over time. After joining international agreements on climate change, most of Vietnam's economic and social processes now include tackling climate change. Indeed, these strategies have been designed depending on the impact of climate change on each zone.

**Aims of the report**: The report will analyse the transformations in three key dimensions: Livelihoods, energy, and infrastructure and transport. These three perspectives represent fundamental changes in the social structure in terms of both physical space and social organisation, thereby providing distinct policy suggestions. Following an analysis of the variation and tolerance of the field study locations and a literature review, we propose a set of indicators to measure the resilience of localities.

**Methodology:** The research was conducted through two typical case studies in Ben Tre and Binh Duong, representing one province in the Mekong Delta bordering the sea and heavily impacted by climate change and one province in the South East region of Vietnam which is less affected by extreme weather events. The study included 40 in-depth interviews including with officials in district and state organisations, entrepreneurs, small traders, workers, and farmers. In addition to this primary data, we also undertook a document analysis. The transformations will be analysed based on our research results and with reference to the FES Socio-ecological Transformation Analysis Framework. Therefore, we define the analytical framework as follows:



# II. CLIMATE CHANGE AND IMPACTS

## 1. Vietnam

According to the Intergovernmental Panel on Climate Change (IPCC), Vietnam is forecast to be one of the 30 countries most adversely affected by climate change (2007). In fact, Vietnam has seen manifestations of climate change in terms of basic climate factors (temperature and rainfall) as well as weather factors (storms, heavy rains, and droughts). Over the past 60 years, Vietnam's average annual temperature (1958-2018) increased by about 0.89°C. Meanwhile, between 1986 and 2018, temperatures increased by about 0.74°C across the country. Average annual rainfall has tended to decrease in the north and increase in the south. In 2015-2016 and 2019-2020, the El Nino phenomenon caused the worst drought in more than 100 years, leading to serious economic damage (National Climate Assessment, 2021).

Over the past decade, natural disasters have claimed thousands of lives every year and cost about 1.5 percent of national GDP. According to climate change scenarios from the Ministry of Natural Resources & Environment (MONRE) in 2012, by the end of the 21st century, when sea levels rise by one meter, an estimated 40 percent of cultivated land in the Mekong River Delta, 11 percent of the Red River Delta, and about 3 percent of other coastal provinces will be affected by frequent flooding and saline intrusion. This will directly affect the lives and livelihoods of about 20 percent of the population. The damage could be as much as 10 percent of GDP per year.

Climate change has a significant impact on the production and daily lives of people in affected areas, in which the poor are affected the most. Especially in recent years, the Mekong Delta has shown the most obvious effects of climate change. Drought and saltwater intrusion have caused a lot of damage to communes in the area, particularly those with special difficulties in coastal and island areas.

The impacts of climate change in Vietnam can be seen in all major sectors: Agriculture, forestry, fisheries, water resources, energy, transportation, and health. At present, these include the impact of climate change on hydrometeorological disasters, resources, the environment, the ecosystem, and socio-economic activities. Meanwhile, the national climate assessment report concluded that climate change may increase strong storms in the East Sea region, rainfall, the risk of drought, desertification, saltwater intrusion, flooding, erosion, and leaching. It also found that landslides will make the land unusable for other purposes. Meanwhile, there is a greater risk of forest fires, and the risk of developing and spreading forest pests and diseases will also increase under the influence of temperature changes affecting the output and value of forest products. Likewise, levels of biodiversity, the structure of species, and the composition of ecosystems will be subject to change.

## 2. The South of Vietnam

The South of Vietnam includes Binh Phuoc, Tay Ninh, Binh Duong, Dong Nai, Ho Chi Minh City, Ba Ria - Vung Tau, Long An, Tien Giang, Dong Thap, Ben Tre, An Giang, Can Tho, Vinh Long, Tra Vinh, Kien Giang, Hau Giang, Soc Trang, Bac Lieu, and Ca Mau provinces. These provinces share a common geographical elevation below 50 meters. The South is a key economic region that plays an important role in the overall socio-economic development of Vietnam. Its geographical location and natural conditions are very favourable and diverse while the area is densely populated. This is also a region heavily affected by climate change, rising sea levels, and saltwater intrusion. Along with the growth in population and socio-economic development, the demand for water is also rising, especially in big cities and key economic regions. Greater demand for water increases groundwater extraction, causing low water levels that lead to the risks of degradation, depletion, and the pollution of water sources.

In the Southern climate region, the average annual temperature has tended to increase in increments of 0.06°C/decade (Soc Trang station) to 0.40°C/decade (Vung Tau station). The average of the whole region has tended to increase in increments of about 0.15°C/decade. Between 1978 and 2018, the absolute maximum temperature tended to increase in increments of about 0.43°C/decade. Average annual rainfall in the Southern region has tended to increase by about 1.87 percent/decade (National Climate Assessment Report, 2021). As for rivers in the Southern region, although only nine provinces border the sea, it includes the Mekong Delta. This is the downstream part of the Mekong River which includes low and fairly flat terrain, the Long Xuyen quadrangle, and the Tien and Hau rivers. The Mekong Delta also contains an interlaced system of canals, so many provinces and cities are affected by saline intrusion. Salinity changes in the area are quite complicated due to the influence of tides in the East and West Seas. However, in short, the salinity levels recorded at most measurement locations in this region are increasing. The changes and trends of climatic and extreme factors appearing in the South include: Storms, tropical depressions, floods, hot and dry sun, and hail. These are becoming more and more complicated.

**Climate change in the Mekong Delta:** The Mekong Delta plays an important role in the national economy and food security. The region covers about four million hectares, accounting for 12 percent of the country's land mass. It has an average elevation of about 1.5 meters above sea level, a population of 18 million people (19 percent of the country's population), and a dense network of rivers and canals. Economically, it has advantages in agriculture, the food industry, tourism, and renewable energy. Indeed, it is Vietnam's largest agricultural production center. The Mekong Delta contributes 50 percent of rice, 65 percent of aquaculture, and 70 percent of the country's crops; 95 percent of exported rice and 60 percent of exported fish; and has a convenient location for trade with ASEAN countries and the Mekong Sub-region.

The Mekong Delta sits at the mouth of the Mekong basin. As such, it is affected by local changes from upstream in the Mekong basin and downstream from the sea. The average flow of the Mekong River is 475 billion $m^3$/year. The upper basin in China contributes only 16 percent of this, with a further 2 percent coming from Myanmar. The remaining 82 percent comes from the lower basin in Laos, Cambodia, and Vietnam.

The Mekong is a young delta, formed during the alluvial accretion of the Mekong River over the past 6,000 years through the "delta tectonic process". Every year, the Mekong River loads, on average, 160 million tons of fine, suspended silt. Meanwhile, 30 million tons of sand and gravel is moved along the riverbed annually. Therefore, the appearance and existence of the Mekong Delta depends on the interaction between the Mekong River and marine processes. As such, the Mekong Delta cannot be isolated from the context of the wider Mekong basin and the sea.

Fine silt and its associated nutrients are a natural source of nutrients for soil, freshwater aquatic ecosystems, and aquatic productivity in coastal areas. Fine alluvium, sand, and gravel play the role of accretion, stabilising riverbanks and coastlines and balancing flow dynamics. When the amount of silt in the flow is reduced, it creates "hungry water" that cannot accrete and causes landslides.

The coast of the Mekong Delta can be divided into three main sections: (1) The 250 km sandy coastline from Tien Giang through Ben Tre, Tra Vinh, and Soc Trang; (2) the section of the east coast from Soc Trang through Bac Lieu to Cape Ca Mau, and; (3) the muddy coast of the West Sea from Cape Ca Mau to the Cambodian border. As a rule, when there is a shortage of sand and gravel transported by the Mekong River to the coast, the coastal section of the river mouth will reduce accretion and increase erosion. Likewise, when there is a lack of fine silt, the remaining part of the East and West Sea coast will reduce accretion and increase the risk of landslides.

The Mekong delta thrives on agriculture, aquaculture and fishery. Aquaculture includes farmed and wild fish and freshwater, brackish water, and salt water fish. Economic sectors in the Mekong Delta such as industry, construction, and services are built from these two pillars. These pillars are based on the main foundation of land and water. The soil and water of the Mekong Delta region depend on the flow and transport of Mekong sediments, rainwater, and interactions with the sea and tides.

In the past, people in the Mekong Delta did not use the phrase "flood season". They only used "flooding season" due to water flowing downstream from June to December every year. Floods in the Mekong Delta are more common and different to those in the Central and Northern regions of Vietnam. Floods in the Mekong Delta rise and recede more slowly.

The Mekong Delta has a special position in the Mekong River Basin. Because it is adjacent to the sea, it is influenced by the semi-diurnal tidal regime. The East Sea has an amplitude of fluctuation twice a day of about 3.5 - 4.0 meters. Meanwhile, the diurnal regime of the West Sea has an amplitude of fluctuation once a day of about 1 meter.

This interaction with the sea creates the inland hydrological regime of the entire Mekong Delta. The influence of tides, reverse currents, and water level changes during the day is called "low water, high water". This changes twice a month according to the lunar calendar called "weed water, poor water" and two seasons called the "dry season" and "flood season". The unique tidal regime with daily low and high water, monthly low and high water, and dry and wet seasons is extremely important for the formation and survival of the Mekong Delta. This hydrological regime shapes the ecology, culture, lifestyle, and livelihoods of the people in the region.

The Mekong Delta faces two global challenges, a regional challenge, and a challenge from human activities in the delta.

*The global challenges are climate change (rising sea levels) and economic globalisation - international integration.* According to global forecasts, the average temperature of the atmosphere will increase. As a result, extreme situations will become more frequent, longer, and more intense. Storms in the sub-equatorial region will become more commonplace. Meanwhile, rising sea levels threaten coastal areas and deltas, with the Mekong Delta one of the most at-risk in the world. The Mekong Delta has to deal with heat, unseasonal rain, inundation, subsidence, coastal erosion, and saltwater intrusion from high tides that penetrate deeper and deeper into the fields.

Regarding rising sea levels: The calculation method for forecasting climate change has changed dramatically,

shifting from one based on the emissions scenario to the Representative Concentration Pathway (RCP). Similarly, the 2016 updated scenario on rising sea levels of MONRE has also seen big changes. Therefore, the new forecast of rising sea levels for the Mekong Delta is as follows:

- In RCP scenario 4.5, which MONRE considers the most likely, by the end of the 21st century, sea levels will rise in the Mekong Delta by 53 cm (32 - 77 cm) in the East Sea and by 55 cm (33 – 78 cm) in the West Sea, compared to 1986 - 2005.

- In RCP scenario 8.5, which is the worst-case scenario, sea levels will rise by 74 cm (48 - 105 cm) in the East Sea and by 75 cm (52 – 106 cm) in the West Sea.

Rising sea levels is a slow and gradual process. The current rate is only about 3.0mm/year. As such, the problem of rising sea levels is more permanent and less urgent than subsidence in the Mekong Delta.

In recent years, following the big flood of 2011, flood water in the Mekong Delta is usually medium to low. The extremely low flood level in 2015 led to drought and salinity in the 2016 dry season. In 2016, the flood returned. However, it was still lower than the average peak for many years. This created the impression that, from now on, the Mekong Delta will no longer flood due to hydroelectric dams blocking the flow. In fact, the cause of low floods is that the Mekong Delta depends on the amount of water in the Mekong River, with an average total flow of 475 billion $m^3$ per year. The rainfall in Laos, northeastern Thailand, and Cambodia is most important here. Rainfall in the Mekong Delta is about 1.400 - 2.000mm/year, contributing 11 percent.

Regarding hydropower, Chinese dams have large reservoirs that store water in the flood season and discharge it to generate electricity. The remaining 11 dams planned on the main stream in Laos and Cambodia operate daily, storing water for about 16 hours, and discharging for about eight hours. In normal years, Chinese dams do not have much capacity to control water resources. This is due to their small contribution and because dams also have to discharge to generate electricity. During dry years, these dams increase water storage and worsen the situation. In 2016, an extreme El Nino caused record-low rainfall across the basin, resulting in record-low flood water levels and severe saltwater intrusion in the Mekong Delta. Therefore, the original cause of drought - salinity in the Mekong Delta - was El Nino. Hydropower is a secondary factor that worsens the situation, but is not its original cause.

El Nino occurs every two - seven years. In extreme times, this can lead to drought. In the context of climate change, extreme weather events are forecast to occur more frequently, ranging from once every century to once every 20 - 25 years. In contrast to El Nino, La Nina can lead to a lot of rain and floods. According to the law of compensation, during a drought due to El Nino, one must always be cautious of La Nina afterwards.

- *The local challenge, in addition to the loss of mangroves and melaleuca forests, comes from sand mining on the Tien and Hau rivers*, which exacerbates the lack of sediment. It also comes from the over-exploitation of groundwater causing subsidence; and from agricultural development that continues to favour quantity over quality, leading to exhausted land and wasted water. Meanwhile, per capita income in the delta is lower than the national average and constantly down from 2000 to the present.

In the Mekong Delta, 93 communes have special difficulties while coastal areas and islands in eight provinces all suffer from the above-mentioned climate change phenomena. Not only that, these communes are located next to the sea, in large estuaries, or are dune communes between large rivers. Therefore, when the effects of climate change in general and saline intrusion in particular are very significant, they are directly and comprehensively affected. For instance, the 2016 drought had a profound and negative impact on all these areas. Due to frequent impacts of natural disasters such as drought, saline intrusion, alkaline soil, etc., these localities are depleted of available resources that are favoured by nature, greatly affecting the natural resources, activities, and livelihoods of the people in general and the poor in particular.

### 3. Vietnam's commitment to climate change

Climate change has become a global issue and is being acted upon on a global scale. Vietnam has committed to participate in global climate change initiatives since the programs, policies, and regulations on climate change have been implemented from central to local levels and realized in the plans and policies of each locality.

***International commitments on climate change that Vietnam has joined since 1992***

- United Nations Framework Convention on Climate Change: Countries, including Vietnam, signed a commitment to join in 1992.

- Kyoto Protocol: Commitment to reduce greenhouse gas (GHG) emissions, effective in countries that have signed the commitment, including Vietnam, since 2005. Following the Kyoto Protocol is the agreement to join the Development Mechanism Clean – a program for developed countries (Clean Development Mechanism - CDM).

- NAMAs mechanism: GHG mitigation actions suitable to national conditions is a commitment to action from developing countries, 2007.
- Paris Agreement on Climate Change: Vietnam submitted an instrument of approval to join the agreement to the UN in 2016.
- Nationally Determined Contribution (NDC): Vietnam's NDC includes the components of GHG emission mitigation and climate change adaptation for 2021-2030.

Following the international commitments that Vietnam has signed, the Government included climate change in the laws of related fields. Since then, specific strategies and action plans have been issued from central to local levels and organizations have been established to implement these programs.

***National laws that mention climate change***

| 2004 | 2006 | 2008 | 2010 | 2012 |
|---|---|---|---|---|
| Law on Forest Protection and Development: promulgating a number of policies related to the field of GHG adaptation and mitigation | Law on Dikes | Law on Biodiversity | Law on Economical and Efficient Use of Energy | Law on Water Resources: Five provisions directly address climate change in ensuring water sources and preventing droughts and floods in extreme and unusual weather phenomena |

| 2013 | 2006 | 2015 | 2017 |
|---|---|---|---|
| Law on Natural Disaster Prevention and Control | Construction Law: shows the state's policy in the design of climate change adaptation works; ensures construction works use environmentally-friendly materials to absorb and reduce GHG emissions | Law on Natural Resources and Environment of Sea and Islands;<br><br>Law on Hydrometeorology: including a chapter on Climate Change Monitoring | Irrigation Law;<br><br>Urban Development Management Bill<br><br>(drafted on 24/11/2017): a key principle of a resilient city is that adaptability must be incorporated in all urban and socio-economic development plans, with a particular focus on disaster-prone regions |

***Programs/strategies to respond to climate change***: There are three main programmes and two important strategies (MPI, 2019) that are applied and oriented to sectors and provinces:

- *The National Target Program on Responding to Climate Change*, 2008 (Decision 158/2008/QD-TTg dated 2/12/2008) is Vietnam's first official program on climate change. It emphasizes the need to integrate climate change response into socio-economic development activities towards sustainable development on a large scale, with consideration of gender equality and poverty reduction. The program was then transformed into a National Strategy on Climate Change starting in 2011.
- *Support Program to Respond to Climate Change (SPRCC), 2010:* This is a financial mechanism established to enhance the expansion of climate change response, such as funding the implementation of the National Target Program to respond to climate change (mainly through soft loans). It also acts as a forum for coordinating climate change policy dialogue between the Government and international development partners. Based on the policy matrix approved by the Prime Minister, every year, development partners (such as JICA, AFD, CIDA, WB, DFAT, and K-EXIM) and the Government agree on policy actions related to climate change as the basis for budget transfer to Vietnam. Most of these transfers are then allocated to climate-related activities.

- *The Science and Technology Program serving the National Target Program to respond to Climate Change, 2011:* This provides scientific and technological evidence (through research on technological solutions for early warning, environmental protection, and natural disaster prevention) serving the response, adaptation, mitigation, and mainstreaming of climate change into strategic plans and implementation processes.

- *The National Strategy on Climate Change:* Starting from the National Strategy in 2011, the most recent strategy is for the period to 2050 (Decision 896/QD-TTg approved on 26/7/2022). It emphasises reducing vulnerability and risk to climate change by improving the resilience and adaptive capacity of natural, economic, and social systems. It also focuses on minimising damage from natural disasters and extreme weather caused by climate change. Other aspects include the effective management of water and land resources; improving environmental quality; maintaining stable forest cover at 43 percent; and providing 100 percent of the population with clean water and safe housing in areas frequently affected by natural disasters. Disaster risk insurance for production and business activities, assets of enterprises, and society is also prioritized, as is reducing GHG emissions.

- The Vietnam Green Growth Strategy (VGGS), 2012: According to Decision 1393/QD-TTg, the objectives of the strategy are green growth, a low-carbon economy, and mainstreaming the enrichment of natural capital in sustainable economic development. Reducing emissions and increasing GHG absorptive capacity have become essential and important indicators in socio-economic development.

***Action Plans:*** The two most important plans related to climate change are the "Action Plan on Climate Change" from central to local levels and the "Five-year Socio-economic Development Strategies/Plans" of the central level and provinces.

- *The Action Plan to Respond to Climate Change:* This began with Decision No. 1474/QD-TTg (2012) approving the National Action Plan on Climate Change for 2012 - 2020. The latest plan is the National Adaptation Plan to respond to climate change for 2021 - 2030, vision 2050. Accordingly, at the provincial level, provinces have a Provincial Action Plan to Respond to Climate Change.

- *Five-year periodical planning system*: This includes a "socio-economic development strategy" and a "socio-economic development plan" for each five-year period, including the specific integration of climate change for each province and sector.

In addition, a number of other plans have been developed according to specific goals or regions. These include the Plan for the Implementation of the Paris Agreement (Decision 2053/QD-TTg, 28/10/2016), the Mekong Delta Plan (2013) funded by the Dutch Government, and the sustainable development plan of the Mekong Delta to adapt to climate change (Resolution No. 120/NQ-CP, 2017). Alongside the main programmes and plans being implemented across provinces and sectors, there are many other circulars, decrees, and decisions which approve specific programmes or particular regulations of sectors and localities related to climate change.

***Organizations implementing programmes on climate change***

- Department of Climate Change under MONRE (2017);

- The National Committee on Climate Change (NCCC), established in January 2012;

- The National Steering Committee on Climate Change (SCCC). At the provincial level, the Provincial Steering Committee on Climate Change (PSCCC) and the Climate Change Coordinating Office (PCCCO) have been established in 63 provinces and cities, depending on the actual operation in the provinces (2021).

- The national monitoring and evaluation system of climate change adaptation activities; Decision 148/QD-TTg (2022).

# III. RELEVANT CONCEPTS

## 1. Medium-sized cities

Medium-sized cities have drawn attention in recent years from both policymakers and academics. This is due to the popularity of medium-sized cities compared to large or global cities in urban classification.

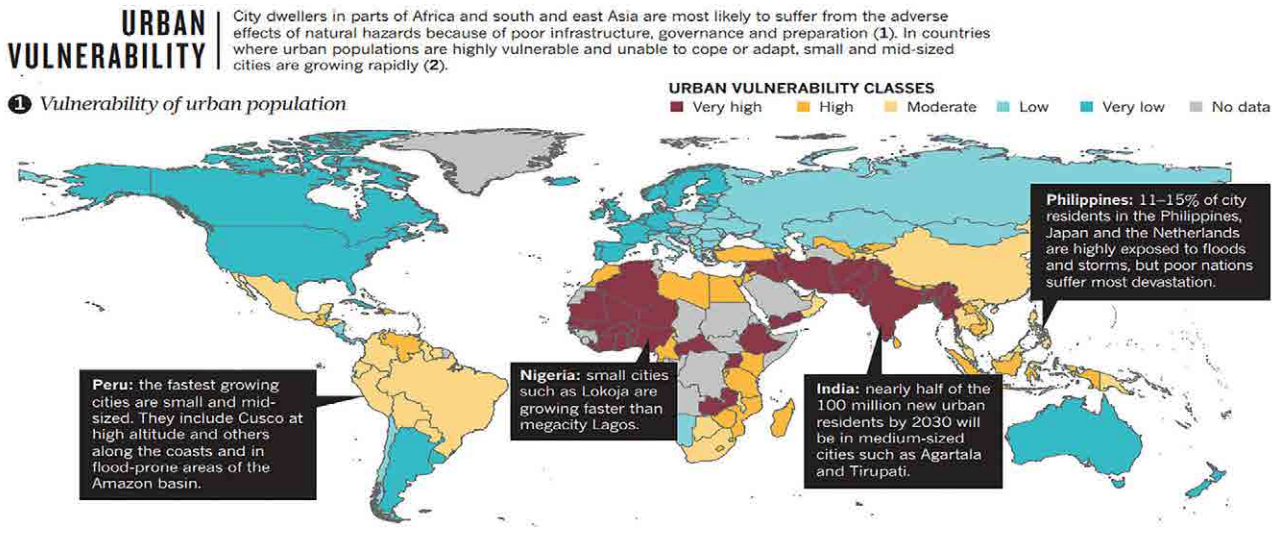
The concept of the medium-sized city comes from the urban hierarchy according to population size. However, there is no universal standard. According to research from Stuttgart (UN-Habitat classification system, September 2016 - before the UN conference on cities in New York), small and medium-sized cities are in a rapid stage of growth. In this study, small cities were identified as having a population of 0.3 - 0.5 million persons and an average size of 0.5 - 5 million persons (UN-Habitat III). In addition, urban classification can also be done based on the population of urban centers, according to the EU. Cities are classified by the following urban levels: S (from 50,000 to 100,000 persons); M (from 100,000 to 250,000 persons); L (from 100,000 to 250,000 persons); XL (from 500,000 to 1,000,000 persons); XXL (from 1,000,000 to 5,000,000 persons); and global cities (over 5,000,000 persons) (Lewis Dijkstra and Hugo Poelman, 2012). Population size is an important criterion for classifying cities in the global urban network. The four urban levels are: Megacity/metropolis (population > 10,000,000 persons); big city (> 5,000,000 - 10,000,000 persons); medium-sized city (> 500,000 - 5,000,000 persons); and small city (from 300,000 – 500,000 persons) (UN, 2016). However, classifications of urban size by population have changed according to the level of urbanisation in different periods. As a result, the criteria for populations living in urban areas only reflect the present and near future.

In Vietnam, urban levels are determined by two different systems: Administrative management and scale of urban development. For classification by administrative management, urban areas are divided into three levels from high to low: (1) Provinces and centrally-run cities; (2) districts/cities belonging to a centrally-run city or province, and; (3) wards/communes directly under districts/cities which belong to a centrally-run city or province. On the other hand, classification by the urban development scale includes: Special urban areas and urban areas by grade from I - V (V being the lowest). Therefore, in Vietnam's urban system, the province/city can be used to analyse city levels based on population size.

However, besides population size, other key indicators are often crucial to the development dynamics of small and medium-sized cities. These include innovation capabilities, networks, and the intensity of cooperation with other cities, as well as transportation, connecting infrastructure, and control through spatial planning approaches in relation to the network and location of individual buildings. In addition, demographic and economic development are interdependent, which contributes to a city's quality of life and attractiveness (Madaleine Wagner and Anna Growe, 2021).

**Figure 1. Urban Vulnerability classes**

*Source: Joern Birkmann (2016) – quoted from the World Bank transparency international fund for peace Munich Re. Sage-centre, UNIV – Wisconsin-Mandison Preview Global risk data platform. ILO.*



Vietnam's cities are mostly classified as urban areas where the population is likely to be vulnerable to moderate risk of disaster. At Habitat III, around 170 countries will adopt the UN's New Urban Agenda. This calls for governments to make cities more inclusive, sustainable, and resilient. Small and medium-sized cities are particularly susceptible to natural hazards and climate change and often have limited capacities to build resilience (Joern Birkmann, 2016). To minimise human suffering, cities need to be able to anticipate, absorb, recover, and learn quickly from adverse events. This requires clear priorities for the most vulnerable and rapidly-growing small- and medium-sized cities. On the other hand, strengthening the resilience of small and mid-sized cities offers opportunities. Smaller cities are easier to manage than megacities. Risk reduction and climate change strategies embedded now can expand as cities grow. Meanwhile, the coordination of and dialogues between different groups are more feasible in small cities (William Solecki et al., 2016).

### 2. Resilience to climate change

Resilience to climate change has been defined in different ways by many organisations. This concept is related to "response" and "adaptation".

*Climate change adaptation:* This is the process of adjustment to actual or expected climate change and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate change and its effects (Noble et al. 2014). The U.S. Global Change Research Program (USGCRP) defines adaptation as "adjustment in natural or human systems in response to a new or changing environment that exploits beneficial opportunities or moderates negative effects" (Congressional Research Service - CRS, 2021).

*Climate resilience: This is considered to come after a disaster and involves the ability to recover from a bad situation and prepare for future problems.* In the context of climate change, resilience is the ability of a system or community to recover from a shock such as a natural disaster. Building resilience requires not only recognising potential hazards like extreme weather phenomena but also understanding the underlying vulnerabilities that can affect recovery from them (BRS, 2022). In a 2012 report on disaster risk management, the IPCC defines resilience as "the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner". Besides, the interagency U.S. Climate Resilience Toolkit also defines resilience as "the capacity of a community, business, or natural environment to prevent, withstand, respond to, and recover from a disruption" (CRS, 2021).

*The concepts of adaptation and resilience are used together in policy or academic research reports.* "Two concepts complement each other, but there are important differences in these terminologies. Basically, "adaptation" refers to a process or action that changes an entity so that it can better survive in a new environment, while "resilience" describes a capacity or ability to anticipate and respond to shocks and recover from their effects in a timely and effective manner. In practice, however, the differences and relationships between resilience and adaptation are more complex and less easily defined" (Sara Mehryar, 2022).

In this report, climate change resilience is understood as the ability of a city to prepare for, respond to, and recover from the impacts of climate change. Cities' resilience to climate change is reflected in the capacity of communities or natural systems to prevent, tolerate, respond to, and recover from the impacts of climate change.

### 3. Urban transformation

In this report, we use the concept of "Urban Transformation". "Transformation" as defined by Polanyi (2001) is a process of social transition from a pre-industrial to industrial society with the theory of liberalism and free market economy, and then a gradual transition to a socialist model. However, with the concept of "urban transformation", we express strategies and actions used to improve the economic, social, physical and environmental conditions of damaged and collapsed urban areas during the urbanization process or by factors such as climate changes. Urban transformation is a regular process in the development of cities. It is based on the constant tension in the relationship between the physical and social elements of the city, always related to the sustained need to update or modernise or simply to transform cities (Maria, 2007, quoted from Mohammed Qasim Abdul Ghafoor Al Ani, 2007). Urban transformation is driven by the recognition of the need and opportunity for radical change towards **sustainable** and **resilient** cities. "Cities are constantly undergoing change, but contemporary urban change is not happening all at once. Cities face many interrelated challenges, including pollution, poverty and inequality, ageing infrastructure and climate change" (Haase et al. 2018; UN-Habitat 2016; Seto et al.; Katharina Hölscher and Niki Frantzeskaki, 2017).

Therefore, *"urban transformation"* is seen as a process happening regularly in cities where the need for development is constant as well as where cities often face the mismatches from development in terms of material and social aspects (pollution, poverty and inequality, degraded infrastructure, etc.) or the effects of climate change. This transformation manifests itself in different ways and always towards a certain need for the development and resilience of cities to problems such as climate change.

Participation is also a component of urban transformation. "Urban transformation embodies the full range of comprehensive strategies and actions and integrated approaches used to improve the economic, social, physical, and environmental conditions of damaged urban areas. It is very important to see urban transformation as a society that is handled and maintained by a participatory approach. It has to match the reality of the city" (Alev Perihan Gurbey, 2011). Besides, urban and digital transformation alongside energy transition are the most important aspects of the great social transformation taking place in Asia and around the world (FES, 2020).

In this report, *"cities' transformations toward climate change resilience"* are considered as transition of the cities to become better resilient to the effects of climate change. In particular, the transformation is mainly analysed from the socio-economic aspect in the operation of society, not from the ecological perspective related to the natural system. Moreover, urban transformation is also considered from two angles: (1) The systematic transformation stemming from the state's policies, and; (2) transformation from the perspective of individual adaptation (livelihoods, migration, lifestyle, using energy and technology).

**4. Livelihood**

Robert Champers was the first person to use this concept, which he defined as follows: "livelihood consists of capabilities, assets, access (storage, resources, ownership, right to use) and activities required essential for life" (Pham Bao Duong, 2008). According to the UK Department for International Development (DFID), "Livelihood consists of the capabilities, assets (including physical and social resources) and activities necessary to earn a living" (DFID, 1998). In other words, a livelihood is the set of resources and capabilities people have, combined with the decisive activities they undertake to earn a living and achieve their other goals and aspirations. Ngo Thi Phuong Lan (2013) considers livelihood as a way of living. Humans use all kinds of ways to ensure their survival needs. People's livelihood activities are based on their available resources such as natural resources, capital, labour capacity, and the development level of science and technology. Individuals or households will choose their livelihood according to their ability. In addition, options are affected by urbanisation. There are many livelihood activities offered according to the new social situation and people can consider the options to be able to adapt to the development of society.

**5. Migration**

According to Tataru (2019), migration represents the crossing of the border of an administrative unit within a minimum period of time. This type of migration includes: Refugee migration, economic migration, as well as the migration of people who move for other purposes or under the influence of other factors, such as family reunification. According to Tataru, there are two types of migration: International migration and internal migration. In this report, we mainly focus on internal migration, specifically from the two survey sites and from Ben Tre and Binh Duong to other areas.

On the other hand, Tataru clarifies the issue of migration further by breaking it down into two categories: Voluntary migration and forced migration. Voluntary migration is based on the initiative and free will of people. It is affected by a combination of economic, political, and social factors at the point of departure (push factors) or the destination (pull factors). Pull factors are often viewed as positive, attracting people to build a better life. In contrast, push factors, according to Tataru, are negative factors such as poor quality of life, underemployment, excessive pollution, hunger, drought, or natural disasters (Tataru, 2019). This report will focus on how the push and pull factors for people from Binh Duong and Ben Tre provinces are related to climate change.

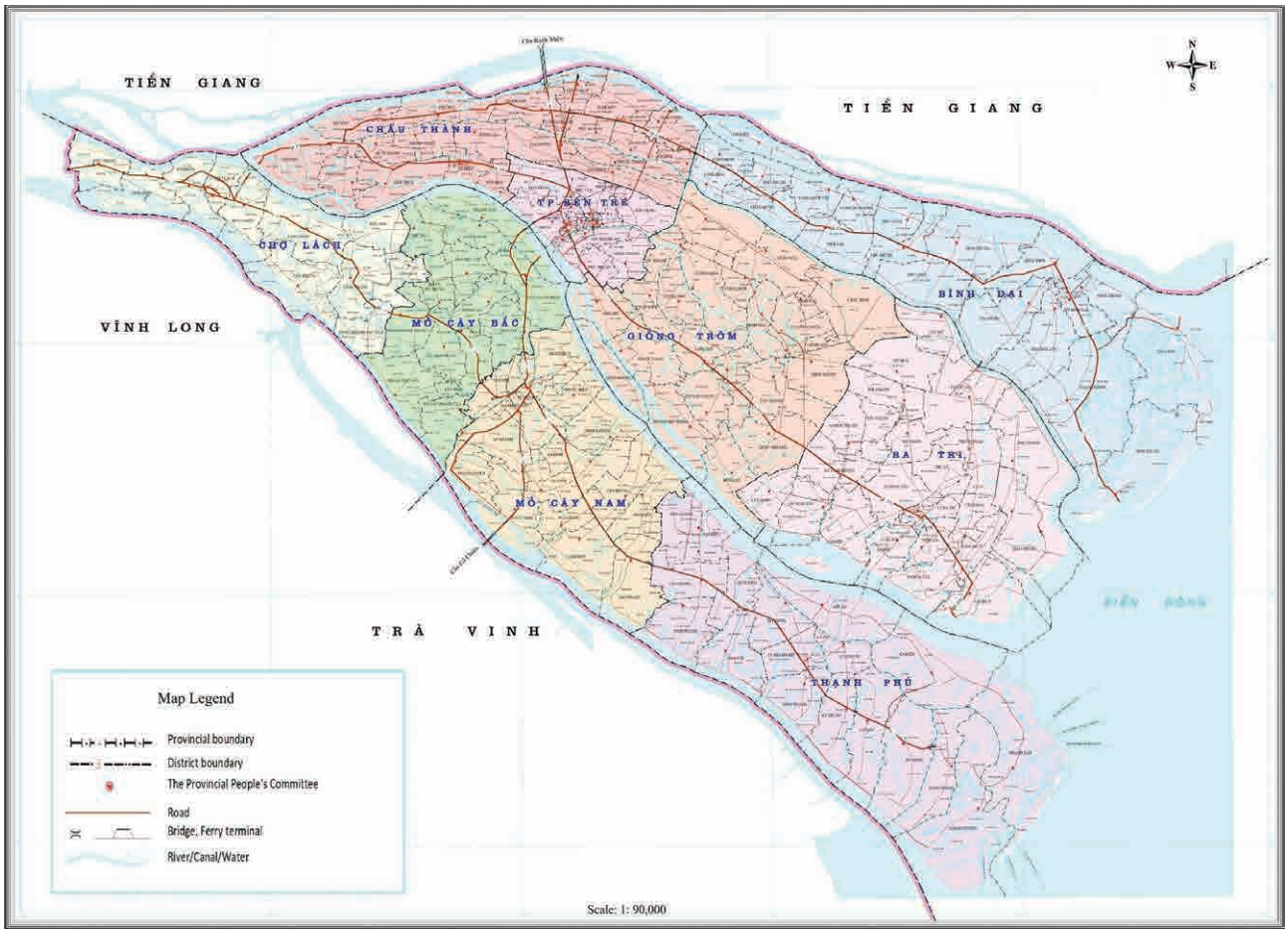
# IV. CLIMATE CHANGE IN BEN TRE AND BINH DUONG PROVINCES

## 1. Ben Tre province

Ben Tre is one of 13 provinces in the Mekong Delta. Located on the edge of the Mekong River, it is downstream of the Mekong River and borders the East Sea.

**Figure 2. Map of BenTre**

*Source: https://bentre.gov.vn*




### *a. Natural and socio-economic features of Ben Tre*

*Geographical features:* Ben Tre is located at the end of the Mekong River and is formed from three islands: An Hoa, Bao, and Minh. Ben Tre has low-lying terrain and is divided by four large rivers: My Tho, Ba Lai, Ham Luong, and Co Chien with a total length of 298 km. The province's natural area is 2,356.85 km$^2$, accounting for 5.84 percent of the Mekong Delta. It has a coastline stretching over 65 km bordering Tien Giang to the north, Vinh Long to the west and southwest, and Tra Vinh to the south. Ben Tre's topography is flat, with many sand dunes interspersed with fields and gardens. There are no large forests, only a few mangrove forests along the coast and estuaries.[1]

Ben Tre has an interlaced river system, estuaries, and coastal areas with an altitude of less than one meter above sea level. Often flooded by tides, it is one of the most vulnerable localities in Vietnam to climate change and rising sea levels. The interlaced system of rivers, canals, and artificial waterways forms a very convenient transportation and irrigation network. Along the main rivers, there is a canal or an artificial waterway every 1 to 2 km. There are over 60 rivers and canals with a width

1 https://www.mpi.gov.vn/Pages/tinhthanhchitiet.aspx?idTinhThanh=18

*My Thanh An commune, Ben Tre city, photo by Phan My Lien*

of 50 - 100 m. In addition to the Tien river tributaries, it is worth noting that there are the following important rivers and canals: Ben Tre river, Cai Mon canal, Mo Cay canal, Mo Cay - Thom canal, Bang Cung canal, Ba Tri canal, Dong Xuan canal, and Chet Say canal - An Hoa.[2]

Ben Tre's climate is characterised by the sub-equatorial monsoon tropical region. It has high temperatures, little variation during the year, and an average annual temperature ranging from 26°C to 27°C. Although adjacent to the East Sea, Ben Tre is less affected by storms than the northern provinces (from about 150° north latitude and above). Ben Tre is affected by the north-east monsoon from December to April and the south-west monsoon from May to November. The north-east monsoon season is a dry period, while the south-west monsoon season is a wet and rainy period. The average annual rainfall is from 1.250 mm to 1.500 mm.

*Socio-economic features:* The province has 23 urban centers including: One city of class I (Ben Tre); three urban centers of class IV (Ba Tri, Binh Dai, and Mo Cay expanded town); 19 urban centers of class V, of which four are district towns (Giong Trom, Chau Thanh, Cho Lach, and Thanh Phu); and 15 commune centers: An Ngai Trung, An Thuy, Tan Xuan, My Chanh (Ba Tri), Phuoc My Trung, Nhuan Phu Tan (Northern Mo Cay), Huong My, An Thanh (Southern Mo Cay), Tien Thuy, Quoi Son, Tan Thach (Chau Thanh), My Thanh (Giong Trom), Vinh Thanh (Cho Lach), Loc Thuan (Binh Dai), and Giao Thanh (Thanh Phu). The rate of urbanisation in Ben Tre is about 20 percent.[3]

Regarding population, according to the 2019 census, the population of Ben Tre is 1,289,098. It has a population density of 538 people/km$^2$ a rise of 0.24 percent compared to 2018. Almost one-in-ten (9.8 percent) people live in urban areas (126,362) while 90.2 percent live in rural areas (1,162,736). Just over half (51.07 percent) of the population is female. The proportion of the labour force aged 15 and over who are in work is 98.33 percent. The rate of people aged 15 and over who are in work and have received training is 11.6 percent. The unemployment rate of the working-age labour force is 1.88 percent and the corresponding underemployment rate is 2.61 percent.

Regarding economic aspects, Ben Tre has a waterway transport system with four main rivers flowing into the East Sea. It also has a system of canals and artificial waterways that provides important transport links between Ben Tre, the Mekong Delta, and the Southern economic region. This is advantageous for socio-economic development.[4] Ben Tre achieved economic scale by 55,258 billion VND in 2020. It recorded a growth rate of GRDP 0.84 percent and GRDP per capita of 42.8 million VND/person/year. By GRDP, at the beginning of 2022, the agriculture, forestry, and fisheries sectors accounted for 35.97 percent. Meanwhile, industry - construction accounted for 19.51 percent, the service sector for 40.71 percent, and product tax minus product subsidies for 3.81 percent. Agriculture focuses on aquaculture, planting coconuts and fruit trees (pomelo and lemon), vegetables, grass for livestock, and rice. However, the area for rice cultivation is decreasing. The forestry economy promotes afforestation, especially mangrove forest planted cork, mangrove, avicennia marina, and casuarina trees. Ben Tre is determined to focus more on key industries including coconut production and processing, seafood processing, and renewable energy in the near future.[5]

According to the Institute of Meteorology, Hydrology, and Climate Change, due to the above geographical conditions, Ben Tre is one of the places most affected by climate change. This directly affects production and the lives of its people. The main effects of climate change in Ben Tre are prolonged heat waves, an increase in average temperatures of 0.1 - 0.3°C, and rising sea levels of about 5mm/year (People's Committee of Ben Tre, 2011). Meanwhile, some other effects from climate change also include saline water intrusion and lack of fresh water supply that negatively affect in many local fruit orchards Frequently occurring natural disasters in Ben Tre include: (1) Rising sea levels and saline intrusion; (2) changes in temperature and rainfall; (3) storms, tropical depressions,

2 https://www.mpi.gov.vn/Pages/tinhthanhchitiet.aspx?idTinhThanh=18
3 Ben Tre News - https://www.facebook.com/1189123861254557/posts/1778701515630119/, 2020
4 https://bentre.gov.vn
5 tapchitaichinh.vn

and cyclones, and; (4) high tides, river bank erosion, and coastal erosion. Climate change affects all sectors and industries in Ben Tre, including: Agriculture, forestry, and fisheries; water resources; transportation; and public health.[6] Of these, aquaculture and agriculture are the most vulnerable (Ben Tre People's Committee, 2011).

### *b. Rising sea levels and saline intrusion*

Due to its location, Ben Tre is affected by freshwater from the Mekong River and tides that push saltwater in from the East Sea. As such, it depends on the flow of freshwater and climate change. The climate and methods of regulating water sources are complicated by saltwater intrusion each year. On average, saltwater intrusion usually occurs in the estuaries of the Mekong Delta from about December to May, peaking at the end of the dry season around April to early May. In the dry season, when the water from upstream decreases, the tide strongly affects the system of rivers and canals. This leads to deep saltwater intrusion both in the rivers and in the fields.

In 2010, salinity of 4‰ penetrated about 60 km inland. In the dry season of 2013, the 4‰ salinity line penetrated about 50 km of the Ham Luong river, 45 km of the Cua Dai river, and 52 km of the Co Chien river. Salinity of 1‰ covered almost the entire province, seriously affecting water supplies for domestic use and agricultural production (Vo Van Ngoan, 2014).

The dry season of 2015 - 2016 recorded very high salinity intrusion. The entire area of Ben Tre province was affected by saline intrusion, including the specialised fruit and ornamental flower growing area in Cho Lach district - located entirely in a freshwater area - which was also affected by saltwater intrusion.

In the dry season of 2019 - 2020, saline intrusion was particularly complicated. Salinity penetrated four tributaries in Ben Tre province. Meanwhile, the Ham Luong river was subject to deeper saline intrusion and higher salinity concentration than the remaining tributaries. Salinity intrusion varies during the day due to tidal influence. At the peak of high tide, salinity of over 4‰ reached the eastern parts of Chau Thanh and Cho Lach districts, about 40 – 60 km from the coast. Salinity gradually increased towards the sea, reaching more than 16‰ and, in some places, up to 20‰. At low tide, salinity penetrated about 20 km deep in the Tien and Co Chien rivers. In the Ham Luong river, it penetrated 40 km deep with salinity of up to 16‰. The deepest salinity peak of the two years was about 20 km apart, with salinity ranging from 2‰ to 9‰ (Southern Institute of Irrigation Science, 2019).

According to the scenario in which sea levels rise by 75 cm by 2100, Ben Tre province will have 725.25km$^2$ of flooded area. This will include the area of specialised rice cultivation (162.81 km$^2$), aquaculture (90.14 km$^2$), and land for fruit trees (40.38 km$^2$) (Ben Tre Province People's Committee, 2011).

Therefore, it is clear that Ben Tre is being heavily affected by saltwater intrusion caused by climate change. This saltwater intrusion process is faster and more severe than in the climate change scenario, making the prevention of saltwater intrusion difficult and causing losses to people. In 2010, saltwater intrusion and drought damaged and reduced yields of 1,575 hectares of rice, 10,162 hectares of fruit trees, and 12,607 hectares of coconuts. Similarly, 300 hectares of shrimp died, affecting the output of 1,500 hectares of shrimp and fish. The total cost of this damage is estimated at 198 billion VND (Ben Tre Province People's Committee, 2011). The process of saltwater intrusion also causes a lack of freshwater sources, especially in the dry season, which will seriously affect production and daily life.

### *c. Changes in temperature and rainfall*

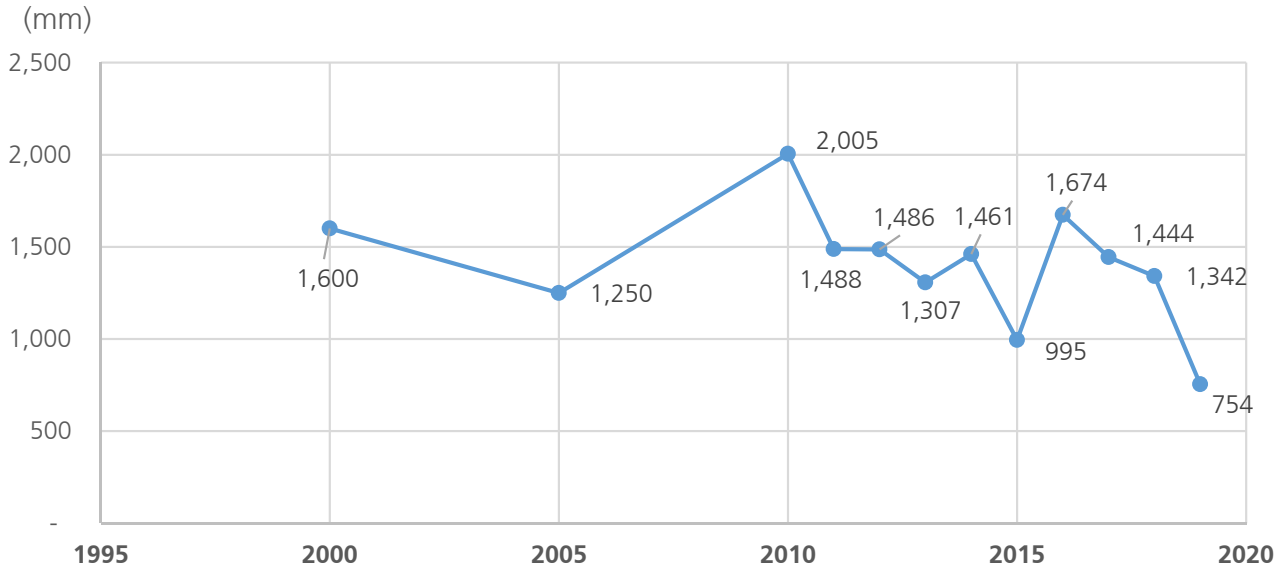
Statistics on annual temperature changes from 1977 to 2010 show that the average annual temperature trend in Ben Tre province has increased markedly. Indeed, 2010 recorded a particularly high average temperature, reaching 29.6°C. The province's average air temperature increased from 0.05 to 0.15°C/10 years in the 20$^{th}$ century, with longer and warmer summers (Ben Tre Province Department of Natural Resources & Environment (DONRE), 2010). Increased temperatures and prolonged heat are two of the factors that adversely affect the living environment of aquatic organisms (shrimp, crabs, clams, etc.), creating conditions for the development of some harmful alien organisms.

Data from 1998 to 2010 shows a negligible increase in rainfall. Rainfall has tended to increase in the range of 11 – 20mm from 1990 to 2006, but this is not significant. However, it is worrying that, in recent times, the rainy season has seen abnormal changes both in time and intensity. In particular, the rainy season tends to happen about two weeks later, rainy days are shorter, and the most intense rain will fall around the end of the rainy season, which is detrimental to production activities (WWF, 2012). Meanwhile, we have seen unseasonal rain in the dry season (December 2011 and March 2012) and the rains bring thunderstorms, whirlwinds, and lightning. Changes in temperature and rainfall affect agricultural production, crop changes, disease spread, and aquatic regimes.

6 https://bentre.gov.vn

**Figure 3. Trend of average rainfall change in Ben Tre Province**

*Source: Statistical Yearbook of Ben Tre. https://bentre.gov.vn*




### *d. Storms, tropical depressions and cyclones*

In Ben Tre, storms usually appear in October and end in December. They most commonly occur in November (Ben Tre Province People's Committee, 2011). Every year, between six and nine storms and tropical depressions directly affect Ben Tre province. From 1940 - 1990, no data was available on storms entering mainland Ben Tre province. However, after 1990, Ben Tre began to suffer from a number of storms, greatly affecting coastal areas (Ben Tre Province People's Committee, 2011; Oxfam, 2008). Because the area is less affected by storms, people have little experience in storm prevention. Therefore, when a storm occurs, it causes damage to property, lives, and production activities. It also disrupts sea dikes and destroys mangroves, which reduces biodiversity as well as ecosystem functions. According to the DONRE of Ben Tre province, its total loss (crops, houses, traffic works, irrigation works...) due to storms and tropical depressions between 2010 and 2014 is estimated at 20.5 billion VND.

In Ben Tre, storms and tornadoes also cause a lot of damage to people. Cyclones often occur at the beginning of the rainy season (May/June) (Ben Tre Province People's Committee, 2011). According to the Department of Agriculture & Rural Development of Ben Tre, between 2012 and 2014, it is estimated that the total damage caused by tornadoes was about 31.8 billion VND, with 895 houses being damaged.

### *e. Erosion of riverbanks and coastlines*

Climate change causes rising sea levels and high tides. For instance, the highest tidal peak in 2013 alone was 199 cm, while the highest from 1984 to 2012 was 197 cm. High tides, combined with fast-flowing water, will cause accidental charging in the fine coastal areas of Ben Tre. This, in turn, will cause damage to protective forests, coastal mangroves, field soil, saline soil, etc. In Ben Tre, coastal erosion often occurs in three coastal districts: Ba Tri, Binh Dai, and Thanh Phu (People's Committee of Ben Tre province, 2011). The rate of erosion of the coastline and coastal areas of Ben Tre province is increasing due to climate change. In 2010, on the 5 – 7 km of coastline in the Bong and Loi dunes (Thanh Hai commune, Thanh Phu district), the average rate of erosion was over 20m/year, killing many protective forests (Ben Tre Province DONRE, 2010).

## 2. Binh Duong province

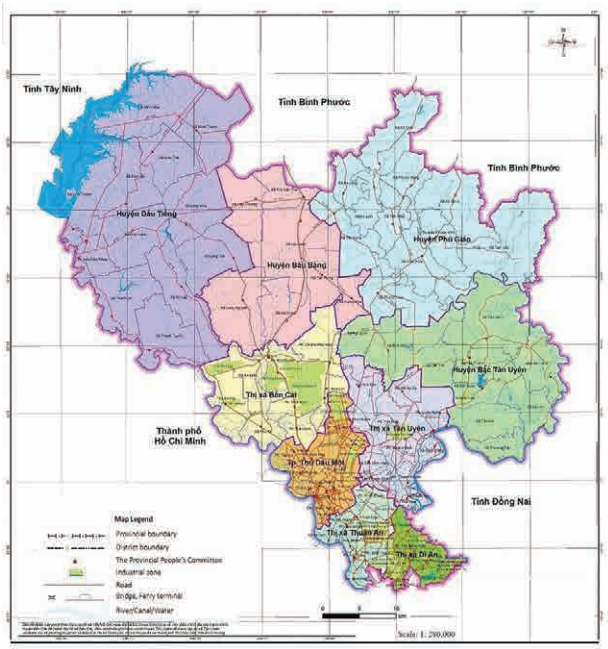
### *a. Natural and socio-economic features of Binh Duong*

*Geographical features:* Binh Duong is located in the Southern economic region of Vietnam. The east borders Dong Nai, the north borders Binh Phuoc, the west borders Tay Ninh and Ho Chi Minh City, and the south borders Ho Chi Minh City and Dong Nai. Binh Duong has an area of 2,694 km$^2$ (about 0.83 percent of the country's area and about 12 percent of the Southeast region's area).[7]

7 https://www.binhduong.gov.vn/gioi-thieu/2020/10/gioi-thieu-chung

**Figure 4. Map of Binh Duong**

*Source: https://www.binhduong.gov.vn*




Binh Duong is located at the edge of contact between the uplift and erosion zone of Da Lat and the accumulation subsidence zone of the Mekong Delta. There are two main fault systems, so the terrain is hierarchical descending from North to South (Binh Duong Geography, 2010). The topographic surface has an average elevation of 60 m to 40 m above sea level in the north and a drop of 30 m to 10 m above sea level in the south. Binh Duong's land is very diverse and rich. It includes grey soil, red-yellow soil, young alluvial soil, alkaline soil, sloping soil, and inert erosive soil.

The climate in Binh Duong is similar to that of the Southeast region: High temperatures, heavy rains, and relatively high humidity. Due to its stable monsoon tropical climate, the year is divided into two distinct seasons. There are almost no storms in Binh Duong. The average temperature ranges from 26°C to 27°C. The average annual humidity is from 76 percent - 80 percent and the average annual rainfall is from 1.800 -2.000 mm. The main river in Binh Duong is the Dong Nai River. This is the largest river in the Southeast of Vietnam, originating from the Lam Vien plateau (Lam Dong) and flowing for 635 km through Binh Duong in North Tan Uyen. There is also the Thi Tinh river, a tributary of the Saigon river. The downstream part of the Be river flowing into Binh Duong is about 80 km long. The province is not convenient for waterway traffic because its rivers have steep banks, many sections of the river bed have reefs, and there are many rapids.

*Socio-economic features:* Binh Duong has a population of 2,568,689 people and GRDP per capita is 151 million VND/year (Binh Duong Statistical Department report, 1 December 2020). It has nine administrative units at the district level: Thu Dau Mot City, Di An City, Thuan An City, Ben Cat (urban center), Tan Uyen (urban center), and the districts of Bau Bang, Bac Tan Uyen, Dau Tieng, and Phu Giao, as well as 91 communes (41 communes, 45 wards, and 5 towns) (binhduong.gov.vn, 2022). Binh Duong has the second-largest number of migrants in general and workers in particular (after Ho Chi Minh City) with 1.2 million people. According to the 2019 census, Binh Duong province had 2.3 million people, with migrants accounting for over half (53.5 percent) of the population (Huy Thinh and Tien Phong, 2019).

Binh Duong is developing its economy in the direction of industry, services, and agriculture. To date, 29 industrial parks have been built (27 are operational) with a total area of 12,670.5 ha. The occupancy rate is 87.4 percent. While, there are 12 industrial clusters with a total area of 790 ha and an occupancy rate of 67.4 percent. Binh Duong also attracts a lot of foreign investment. As of 2020, the province had attracted 3,928 investment projects and USD 35.4 billion. This leads Binh Duong ranking third in the provinces of country in terms of attracting foreign investment, just below Ho Chi Minh City and Hanoi. At the same time, Binh Duong has 48,456 domestic enterprises. Many new and modern urban areas have been formed, the most typical of which is "Binh Duong New City".

Agriculture only accounts for 3.15 percent of the local economy. However, in recent years, Binh Duong has aimed to build hi-tech agriculture. Today, Binh Duong has the second-largest number of farms in the Southeast region and the fifth in the whole country. The total area of hi-tech application in cultivation in Binh Duong has reached 5,763.5 ha. The province has four hi-tech agricultural zones: Tien Hung (North Tan Uyen); Tan Hiep and Phuoc Sang communes (Phu Giao); Vinh Tan (Tan Uyen); and An Thai (Phu Giao). These aim to develop areas for the specialised cultivation of rubber trees, speciality fruit trees, and safe vegetables associated with processing and consumption along the value chain. The area for urban agriculture is about 172.2 ha with the planting of valuable crops such as vegetables, mushrooms, fruit trees, orchids, and ornamental plants. Meanwhile, hi-tech application in the livestock industry continues to develop with 146 farms investing in breeding chickens, egg laying, and broiler chickens; 229 raising market pigs and breeding stock; 30 raising ducks for meat; and one raising dairy cows.

The socio-economic situation in Binh Duong province has changed from agriculture to rapid industrial development, attracting a large number of migrants in the process. This economic development has led to a change in the surface

temperature of the province. In general, before 2016, the effects of climate change had not been particularly significant. Meanwhile, economic development and restructuring has had both positive and negative impacts on the environment. However, under the general impact of the global climate change trend, there is a tendency for increases in temperature, rainfall, and changes in other phenomena. Extreme weather events are becoming more and more frequent. This will affect the production and daily life of people.

### *b. Temperature change*

In 2002, the lowest average surface temperature in Binh Duong province was 17.2°C in March and the highest in April was 41.2°C. Meanwhile, in 2016, April saw the lowest average surface temperature of 16.9°C and March had the highest average surface temperature of 37.5°C. After 15 years, the minimum surface temperature in 2016 increased by about 1.1°C compared to 2002. Over the same period, the maximum temperature changed slightly. However, the average temperature fell by nearly 1.5°C: From 30.8°C in 2002 to 29.3°C in 2016. This fall in temperature is due to bare land in the north of Binh Duong being converted to perennial industrial crops between 2002 and 2016, increasing vegetation cover. Areas with reduced temperatures accounted for about 57.5 percent of the total area planted with industrial crops from 2002 to mature crops in 2016. Areas with increased temperatures accounted for about 16.6 percent because non-agricultural land accounted for a large proportion in 2016 (Nguyen Huynh Anh Tuyet, 2017). From 1980 to 2018, the average temperature in Binh Duong province increased by 0.022°C/year (in the past 30 years, it has increased by more than 0.6°C) (Binh Duong Province People's Committee, 2021).

Due to the influence of climate change and global warming, the surface temperature of Binh Duong province is rising. The Dau Tieng area has seen surface temperatures increase by about 0.41°C and over 77 percent of natural areas have experienced an increase in surface temperatures. The spatial distribution of average temperature variation in Binh Duong province, according to RCP scenario 4.5, shows that the average temperature for the period to 2025 compared with the baseline will increase from 0.6°C - 0.7°C. The temperature distribution gradually increases from Dau Tieng district to Di An City. Up to 2030, compared with the baseline, the temperature will increase by 0.8°C - 0.9°C in Phu Giao, Tan Uyen, Thu Dau Mot, Thuan An, and Di An. In general, the temperature in the province is quite similar.

### *c. Rainfall variations*

The weather regime in this area is divided into two distinct parts. The rainy season (from May to October) accounts for 85 percent of total annual rainfall. In the first months of the rainy season, heavy showers often appear and then stop completely. July, August, and September are usually rainy months, with heavy rains lasting 1 - 2 days and nights continuously. Average rainfall has increased by 8.17 mm/year in Binh Duong.

Average annual rainfall is 1.772 mm, with the highest on record (1942) being 2.683 mm and the lowest (1962) 1.376 mm (Le Xuan Thang, 2011). The average annual rainfall in Binh Duong province does not change much. However, at present, due to the influence of climate change, there is unseasonal rain. As a result, the total amount of rainfall fluctuates. In February 2020, due to unseasonably high rain in many places (Dau Tieng, Di An, Ben Cat, and Phuoc Hoa), rainfall was 10 – 34 mm above average. On the other hand, rainfall in So Sao and Tan Uyen was 4 – 5 mm below average. Meanwhile, average air humidity (60 percent) was 16 percent below the multi-year average, and total evaporation (128.5 mm) was 10.4 mm above. The strongest wind (17 m/s) in a northeasterly direction occurred in February (Binh Duong Province Hydrometeorology, 2020). Because there are no storms in Binh Duong itself, it is only affected by nearby storms (Truong Van Hieu, 2012).

According to the spatial distribution of average temperature variation in Binh Duong province in RCP scenario 4.5, in 2025, rainfall will increase from 7.2 percent to 9.2 percent in Thu Dau Mot City. This will be less than other towns and districts. By 2030, rainfall will increase from 8 percent to 10.2 percent, distributed similarly to that of 2025. The rainfall in 2050 will continue to rise, with the largest increase in Dau Tieng district.

In general, temperatures and rainfall in Binh Duong province tend to rise. This causes an increase in humidity, the number of hours of hot weather, the occurrence of unseasonal rains, and changes in water levels. In June 2019, the average water level in the province was on a downward trend (0.28 m) compared to May and falling (0.20 m) compared to the same period in 2018. The average water in all strata tended to increase over the same period two years ago (by 0.05 m) and five years ago (by 1.10 m).

# V. TRANSFORMATIONS TOWARD CLIMATE CHANGE RESILIENCE

In this section, transformations will be discussed in three dimensions: livelihoods, energy, urban planning and transport. Policies as well as actual activities of people or businesses will be presented. The policies follow the National Strategy on Climate Change in 2011 which are encompassed into city or provincial socio-economic development plans. Local governments tend to address the links between these policies and sustainable urbanisation within the cities' framework, ensuring the specificity of each region.

***In Binh Duong***, there are changing temperature and rainfall. The temperature can change due to urbanisation. As such, it is difficult to tell whether the increase in temperature is the cause or the consequence of climate change. Currently, the implementation of policies and programmes on climate change has not been clearly reflected in local activities. Starting in 2012, Binh Duong Provincial People's Committee approved the "Binh Duong Provincial Climate Change Action Plan for the period 2013 - 2015, 2016 - 2020". Most recently, it published the "Plan for the Period 2021 - 2030 and Vision 2050" (Decision 430/QD-UBND).

***In Ben Tre***, the climate change impact is more obvious, so many programmes have been implemented for the recent years. Ben Tre was one of the first provinces to issue the "Framework for an Action Plan to Respond to Climate Change" (Decision 1720/QD-UBND) in 2009. Then, in 2011, it approved the "Project to Respond to Climate Change and Sea Level Rise in Ben Tre Period 2011 - 2015 and Orientation to 2020" (Decision 1983/2011/QD-UBND). The "Plan for the Period 2021 - 2030" (Decision 1012/QD-UBND) is the most recent.

*Coconut farm in Ben Tre, photo by Son Thanh Tung*

## 1. Livelihoods

### *a. Impact of climate change on livelihoods*

**Regarding farming, in Ben Tre province,** saline water intrusion has created numerous effects on the life and production of people in the province, ranging from coastal to inland districts. Many places in the province, specializing in growing fruit trees such as durian, rambutan, pomelo and coconut trees, have suffered from salinity intrusion particularly in the dry season in 2019 – 2020 and continuously until today. Similarly, the areas used for aquaculture since February 2020 have been affected by increased salinity and saltwater intrusion. Areas between the Ham Luong and Ba Lai rivers, in a brackish water ecological zone mainly cultivating perennial crops, fruit trees and rice, suffers from saltwater penetration through the canals, affecting agricultural productivity. Saltwater intrusion in the dry season of 2019 - 2020 affected rice crops heavily. Areas next to the East Sea in the saltwater ecological zone specializing in aquaculture are affected by salinity and thereby damaging agricultural production and aquaculture (Thuy Vy et al, 2021).

*Regarding husbandry,* due to failure of crop due to salinity, there is a scarcity of straw material. Ben Tre province has a total herd of over 150,000 cows. However, due to this lack of straw, farmers have had to sell fewer cows at a cheaper price (10 million VND/head lower than in previous years). Ba Tri district has the largest herd of cows in the province (about 80,000). There, the demand for straw is very large. Farmers have to buy straw, with prices ranging from 15,000 - 30,000 VND/roll of straw ranging from 12 kg to 15 kg. Drinking water for cows is also expensive. The same applies for pig and duck farming. The sudden use of saline water causes digestive disorders such as diarrhoea, anorexia, thirst, and abdominal pain causing epidemics and mass deaths, adversely affect the growth and development of livestock (Cong an Nhan dan, 2016).

*Regarding aquaculture,* the situation of drought and salinity in the Mekong Delta in 2020 was earlier and more severe than 2016, significantly affecting aquaculture activities. In Ben Tre alone, more than

3,000 ha of freshwater shrimp ponds and nearly 1,500 ha of pangasius, catfish, and sesame ponds were affected. Saline intrusion changes the farming activities of the people. This unstable environment, combined with high salinity, changes the structure of the aquatic ecosystem. That, in turn, causes disease, shock, and death of aquaculture products and farming area being reduced to half that originally planned. Damage to aquaculture leads to a slump in the seafood processing and export industry, affecting the economy of households and businesses.

Saltwater intrusion causes freshwater (surface water) sources to become saline. This leads to a shortage of fresh water for daily life and agricultural production. This is particularly acute in the long dry season, especially for coastal areas. Meanwhile, the demand for fresh water has increased. This leads to an increase in the exploitation and use of groundwater to meet people's daily needs, crop cultivation, and livestock raising in the province. This increased exploitation of groundwater causes the groundwater level in the area to decrease rapidly. That, in turn, affects the water balance in the region and increases saltwater intrusion deeper into the field (Ben Tre Province People's Committee, 2011).

***b. Livelihood transformations***

The economic, particularly agricultural, landscape of the Mekong Delta has changed drastically with the livelihood transformations due to climate change. A study by Smajgl and colleagues (2015) found that a large proportion of households in the western part of the Mekong Delta have already invested in adaptation to salinity levels by cultivating shrimp and other aquaculture products. Therefore, investments in infrastructure for keeping out saltwater have therefore become less favorable.

In Ben Tre, a lot of farmers have shifted from fresh water agriculture such as rice, fruits and vegetables to brackish or salt water aquaculture or a combination of both freshwater or brackish water with saline water farming such as growing rice in the rainy season and raising shrimps in the dry season. For example, in Giong Trom district, farmers in Phuoc Long and Hung Long communes have changed their farming practices since 2017 from rice to shrimp farming due to the impact of saline intrusion as one farmer said:

> *In the past, this was rice field. Then, the pond was dug up to give space to shrimp farming."*

Few farmers, especially those in coastal and brackish water zones, remain growing rice, fruits and vegetables but have shifted to planting perennial (mainly coconuts) crops and aquaculture (such as shrimp and clam farming). The reason for the change in crop structure is that perennial crops are easy to grow, quicker to recover from salinity and has good salt or flooding tolerance. Especially coconut trees, a popular tree species in Ben Tre and other Mekong Delta provinces, are easier to care than fruit trees. A farmer analysed the benefits of planting coconut trees as follows:

> *Although the income from growing coconuts is not as high as pomelo or jackfruits, growing fruits needs a lot of hard work. We have to spray pesticides and fertilizers most of the time. Meanwhile, growing coconut trees is easier. We only spray pesticides and fertilizer once a month, or even every three months. In the past, the income of a grapefruit was VND 60,000 to 65,000. If I plant a hectare of grapefruits, I would earn a lot. As for growing coconuts, the income is not that good, but I think it can make a more stable life. Coconut trees are very durable." (No. 08).*

Though, the productivity of coconut trees is also damaged by salinity as one farmer said:

> *Coconut trees are tolerant to brackish and even salt water. In Thanh Phu area, near the sea, coconut trees can still have fruits. However, their fruits are not large. The large fruits of Siamese coconut can be sold for 50,000 (per stand) whereas small fruits are sold for only a few tens of thousands Vietnam dong." (No. 11).*

Another farmer who has shifted from planting jackfruits to coconuts has a similar comment:

> *Coconut trees are still alive. It can tolerate salt for 1 to 2 months. But if saline water remains for too long like what happened that year, the coconut trees were also damaged and could not be productive anymore." (No. 11).*

Some farmers remain growing the same crops but switch to short-term farming. For example, in the past, they used to grow jackfruit trees, but now, although they continue to grow the same trees, they harvest it much earlier, after about three months. The reason is that short-term planting is less risky, helping them avoid saltwater intrusion as one farmer said:

> *After being affected by saline intrusion causing the death of trees such as jackfruits, durian and rambutan that were bearing fruits, people switched to short-term planting. They do this because seedlings or baby jackfruits can be harvested in very short time, just about a year or more then they can sell it." (No. 12).*

Perennial crops are profitable and aquaculture is even more. One farmer referred his increase of income since he shifted his farming practice. Though, he faced a lot of challenges:

> *Since I shifted to shrimp farming, the income has increased a lot. But for two years now, I have not earned a penny. I have to work at the construction sites to make ends meet."*

In addition to shrimps, farmers raise other products such as clams and oysters. For shrimp farmers, the changing weather can affect the productivity of shrimp farming and therefore they have to use medicine to prevent shrimps from diseases. One farmer said:

*"I have used kind of anti-shock medicine to prevent shrimps from diseases caused by the changing weather." (No. 03).*

Some farmers change the variety of shrimp to better suit the changing weather. One farmer said he switched from raising black tiger shrimp to white shrimp for the following reasons:

*"Since 2011, I have switched from black tiger shrimps to white-leg shrimps. Since I switched to white-leg shrimp farming, I haven't returned to black tiger shrimp farming anymore. It is because white-leg shrimp farming takes shorter time as they grow faster." (No. 01).*

Another farmer also referred to the same application:

*"I have changed the way I raise shrimp continuously for the past 5 years. The same goes for the seed. I'm constantly changing the varieties. I do not raise one variety for more than 3 crops. I have to shift to new variety as it is not effective anymore." (No. 03).*

Farmer also knows how to make the best use of their land for other purposes such as renting besides growing short-term flowers as one farmer shared:

*"As for salty land that people cannot cultivate, they will rent it out for trading flowers. Some people plant marigold flowers, raspberry chrysanthemums, or chrysanthemums to sell at New Year seasons. These varieties can grow in short time, only about 6 months." (No. 03).*

Some farmers are unable to invest in other forms of agriculture or aquaculture due to lack of capital or skills, so they have to abandon their land or sell it and work as hired laborers or migrate to other places. This is shared in the group discussion (excerpt from No.07) as follows:

*Question: When salinization occurs here, do people abandon their crops?*

*Participant A: A lot*

*Participant B: A lot, sometimes they have to sell their land.*

*Participant C: Those are the households that grow fruit trees.*

*Question: People give up their land and then switch to another profession or do they go anywhere else?*

*Participant A: If people don't have capital for reinvestment, they go to work as hired laborers or workers. If some households still have capital, they can continue doing their jobs.*

*Participant D: Most of the people here don't have the ability to change.*

Besides changing crops or switching from freshwater to brackish or saltwater water farming, people actively raise more livestock to increase their income or grow vegetables or grass for cows as a farmer shared this view (excerpt from No.07):

*"We raise cows, goats as these two are popular in here. We also raise pigs, ducks, or chickens for extra income. We also raise vegetables or grass to raise cows. If the family is only elderly people, they only take care of the garden. My family is retired people, so we live on pensions. If they are farmers, they have to raise more livestock."*

*Goat raising in a household in An Duc commune, Ba Tri district, Ben Tre city, photo by Pham Thi Bich Nga*

*Shrimp farming in An Duc commune, Ba Tri district, Ben Tre, photo by Pham Thi Bich Nga*

Farmers consider livestock to be more profitable than rice farming although raising livestock requires more investment in farms, seeds and techniques. Some farmers told about this point in a discussion:

*Interviewer: If you change your farming practices, will your income be the same as in the past?*

*Farmer A: In general, raising livestock is better than rice farming, because rice farming is basically enough to eat but not rich. You have to work part-time outside. Clinging to the garden is just enough to survive, not to be well".*

*Interviewer: Have you encountered any difficulties during the transition to animal husbandry?*

*Farmer B: I have had some difficulties. The first is farm investment. For example, if you raise goats, you must have a piece of land for a barn. Investment must be sufficient otherwise you cannot make a profit".*

*Farmer C: I need tens to hundreds of millions to build a barn and buy seeds. Then there are technical challenges. Although there are several livestock training programs, the training content is only sketchy".*

In particular, cows and goats have good resilience to harsh weather such as drought and saline intrusion. Besides, the conversion of crop land to grass land to raise cows and goats leads to greater efficiency and more stable incomes. Today, husbandry can bring 3 - 4 times higher return than rice farming and contribute to poverty alleviation in households, boosting economic development in the province (Huynh Phuc Hau, 2021). At the moment, there is a herd of more than 227,000 cows and over 185,000 goats, mainly on a household scale, in the province (Dong Khoi, 2021). In the future, Ben Tre province will focus on supporting people to join associations and cooperatives in livestock production to create stable output.

The provincial committee has support policies to help farmers and enterprises transform their livelihoods due to climate change. One of the policies is to provide trainings to farmers who shift to new farming practices. They are guided and trained on how to do aquaculture such as shrimp farming by local officials at the provincial, district or commune level. Though, the trainings provided are very superficial and farmers mainly have to learn farming practices techniques by themselves. About this, one farmer said: *"In the beginning, I also went to attend learning groups, trainings, and seminars held at commune, district, and provincial levels. I also learned from the predecessors especially those who failed" (No.07).*

Another farmer also confirmed that they have to manage themselves rather than supported by the local government:

> *No. That is my business. Usually, the local government organizes a seminar and then I will go there to learn. The state has little to do except providing that seminar. Shrimp farming is your own business." (No. 07).*

Farmers have also converted to new hi-tech varieties as one local official shared this view as follows:

> *We have to find partners in countries like Malaysia, Taiwan, and China to buy new plant varieties. For example, in Thanh Phu commune, there is a high-tech shrimp farming model, and here in this commune, we have a high-tech seedling model." (No. 07).*

High-tech farming requires investment of capital and technology and only a few farmers can afford. A farmer who grows cabbage with hydroponics shared his experience:

> *Only capable farmers who are technically well-supported can convert to high-tech farming such as hydroponics. They will build a trellis to cultivate plants on high, so it is not affected by rising water. Since they do indoor farming, they actively water and fertilize plants and thus the yield will be productive. But this type of farming requires a lot of investment. If an ordinary mustard plant raised in a natural environment only costs 10,000 VND to become grown up and profitable (after going through small traders, it can be sold at 12,000-15,000 VND), vegetables grown hydroponically in cages will cost over 20,000 VND (through traders it is about 30,000 VND)." (No. 07).*

According to a farmer's view, the first challenge is capital to invest in building a greenhouse for hydroponics farming. The cost of building a hi-tech greenhouse is very high that is about VND 25 million/square meter, many times more expensive than building a house. The second challenge is technology. Farmers are still used to traditional farming methods, so even with support and trainings, they are still very slow to absorb new technology. Besides, the output of the market is not stable and agricultural product prices are volatile. If the productivity is high, the price will be depreciated; if the price is good, the productivity is lost. Therefore, farmers are afraid to invest a lot in high-tech agriculture. Only farmers with capital and high determination can do it.

Though, there remain a lot of people who do not prefer farming transformations and have low motivations for this as a study by Hong Quan Nguyen and his colleagues (2019) shows that. Quite a few farmers do not want to change their farming as they are afraid of failure (such as shrimp diseases) or low profits or have no capitals or in lack of technical capacity. One farmer said:

> *Some people remain working in the same garden or fields, take care of it as before, and accept low productivity. They will combine with doing other jobs such as small business and handicrafts."*

A farmer mentioned challenges in terms of capitals and environmental problems when doing aquaculture farming:

> *It is easy to raise clams but it needs huge investment capital. Shrimp farming is now very difficult. Besides, the shrimp farmers are very scared of oil discharged from boats on the rivers." (No. 01).*

Hong Quan Nguyen and his colleagues consider motivation for change is very important and recommend that the livelihood transformation initiatives need first to focus on raising farmers' motivations, for example, via showcasing livelihood models (including market linkages). In addition, efficient water resources, financial needs and agriculture training incentives are essential for successful livelihood transformation. Initial investment is a significant factor to consider in transforming livelihoods. For example, intensive shrimp farming for either families or commercial farms is not suitable for farmers with low financial capacity whereas limited access to capital remains a considerable barrier in this process.

Consequently, crop diversification through integrated and poly-culture models have been appropriate options for farmers with low financial capacity. For example, integrated models, such as rice-shrimp or mangrove-shrimp are optional as they are less risky due to the availability of a back-up crop in case the main crop fails, as well as being more environmentally friendly.

Most of small farmers only employ semi-extensive shrimp farming as this doesn't need a lot of capital and in case they fail they do not lose much. A farmer revealed:

> *Like this year, I released 10,000 seeds which are in 2 times (about VND 9 million to 10 million each). If I win, I'm happy, but if I fail, I don't lose much. So, I release seeds in batches, month by month. So, every month, I have shrimp, crabs and fish for sale and just let it go, earn as much as I can. In the past, every time I harvested, I earned dozens of VND millions each time. Now I could get only around VND 4 to 5 million" that makes me happy enough." (No. 03).*

Water resources are essential to consider when deciding on appropriate transformative models. Each livelihood model, given its favorable agro-ecological conditions, can only be deployed in a suitable agro-ecological zone. Models such as commercial eel farming using canvas tanks, mixed male giant freshwater prawn–coconut farming, semi-intensive male giant freshwater prawn farming and integrated rice-cash crop and cattle are best suited to areas where freshwater is available. By contrast, brackish shrimp farming, of which there are several types, is the best option for coastal areas with more than six months of salinity. For example, the adoption of the male giant freshwater prawn–coconut model by coconut farmers (shrimp ponds with the existence of dredged channels inside coconut farms) in freshwater areas in Thanh Phu district and the mangrove–shrimp model in saline water areas of Binh Dai District have been successfully deployed. In addition, people have started storing fresh water to use for agricultural production and daily activities in the long dry season (Propaganda Magazine, 2016).

There are quite a few obstacles to the livelihood transformation. Access to information is a kind of barrier. In the meanwhile, to be able to react to market opportunities and reduce risks of, for example, price collapse from limited market volumes, farmers need more information on market prices in real-time as well as (seasonal) market demand predictions. Good, medium-term predictions of weather, salinity conditions, and markets can help farmers decide what to produce.

There are also cases where certain interventions have reduced options for diversification and increased conflicts over salinity and freshwater management, such as the area affected by the Ba Lai sluice gate in Ben Tre. It has been suggested to assess (and possibly address) the social and environmental effects of this sluice gate to prevent an increase in conflicts between different water users in this and future similar cases. The transformative process has also resulted in additional environmental challenges. The conversion of coastal land into shrimp ponds has taken place uncontrolled. The innovation in drip and sprinkler irrigation has caused increased demand for pumped groundwater.

In the farming process, there is a conflict of interest between rice farmers and shrimp farmers, especially regarding the use of water resources. In this case, it is a conflict between the shrimp farmers' use of salt or brackish water and the rice farmers' freshwater. One farmer expressed this view as follows:

> *There is conflict between shrimp farming and rice farming. In the freshwater field, shrimp farmers discharge salt water into the canal which rice farmers take in to grow rice, then it affects the rice. So rice growers have therefore to be alert and always have to check the water before using it. If they accidentally use that salt water, they will lose their rice crops. Rice farmers and shrimp farmers are always at odds with each other." (No. 11).*

In addition, there are other conflicts as to whether fertilizer use by rice farmers will affect shrimp farming or conversely, saline water vapor from shrimp ponds affects rice fields. One way to help farmers switch to aquaculture but not much affected by climatic factors is extensive farming. At that time, although their income is not high, they feel more secure. One farmer said:

> *I raise shrimps extensively. But if I do shrimp farming intensively, I will be afraid of the weather. Now those who are about to raise shrimps, they have to spread lime because it's too much alum." (No. 12).*

Some farmers no longer do agriculture or aquaculture, but go to work in local companies instead. These companies are mainly in food processing and textile. Incomes from working in companies are higher and more stable. Though, working in companies has lower income than aquaculture. One farmer shared this view:

> *About two years ago, I was not directly involved in shrimp farming but hired an engineer and another worker to do it. I went to work for a construction company. If shrimp farming is successful, I can earn one hundred or two hundred million VND per crop. Meanwhile, working at the company, the salary is only about VND 100 millions a year which is not enough to raise children. If I stay at home and do shrimp farming, let my wife go to work, I can do more things such as taking care of children and doing housework." (No. 12).*

Even now, finding laborers in agriculture is more difficult than before because they have gone to work in companies. One farmer said:

> *Thanks to companies in the locality. Now it's very difficult to find a gardener for me. They have all gone to work at companies. There are some big companies in Chau Thanh like the clam company which is very big and attracts all the local labour forces. Working in companies bring much better income than farming. My family has two or three children who all work for companies." (No. 09).*

The local government organizes vocational training classes to help people change jobs. Usually, they will hold classes that teach common trades such as sewing. A local official said:

> *The government has a policy on vocational training for people to switch to other jobs. We organize sewing classes. Several companies will cooperate with us. Once created, they will recruit all." (No. 06).*

Climate change has also impacted businesses. In Ben Tre, businesses also have to change their business strategies and diversify their products to maintain revenue. One business shared these ideas as follows:

> *As we have exported less agricultural products, we have to switch to other business forms such as selling on Shoppee and Ladaza. I have flexibly cooperated with those companies to provide online products. In addition, there has been long-term cooperation with companies on ceramic and wood. Our cooperation has been stable for many years. I will start some other products besides carton such as honeycomb paper, gift boxes, and paper bags. I will try to diversify paper products." (No. 15).*

**Binh Duong province**

One interesting finding of this study is that there is not as much impact of climate change in Binh Duong province as in Ben Tre province. Climate change in Binh Duong is mainly due to hotter weather and erratic rain. While people in Ben Tre mainly work on agriculture and aquaculture, people in urban areas in Binh Duong are mainly doing business or working in companies and factories and therefore the impact of climate change on their livelihoods is minimal. They do not have to deal with saline intrusion and its impact on livelihoods like in Ben Tre either, as one person shared:

> *Climate doesn't have much of an impact on my business. I feel that my life is well and stable because Binh Duong's economy is now developed, so I have no intention of migrating to another place to live." (No. 25).*

However, for farmers engaged in agriculture such as rubber plantations, they also feel the impact of climate variables on the yield of the tree:

> *This year I feel the rubber yield has decreased significantly. In previous years, the output was also normal. I don't understand why this year the productivity has decreased significantly, about 20* percent*. Normally, I could harvest 60-70kg a day but now only 50kg." (No. 25).*

***c. Migration as a solution***

Climate change in Vietnam can be easily seen in storms, floods, and droughts. These seriously affect agricultural activities (crop failure, saline soil, etc.), pushing farmers into crisis (World Bank, 2010). The poverty that follows leads to people's permanent or temporary migration (Adger, 1998). In recent years, countries have come together to make decisions on migration because of natural disasters and climate change. However, the issue remains unresolved (de Sherbinin et al. 2011; McAdam and Ferris 2015 cited by Miller and Dun, 2019:2). Therefore, migration issues and policies still need to be of primary concern. More clarification is required on some of the related concepts below, including transition, adaptability, and migration.

Ben Tre and Binh Duong are both small and medium-sized cities. However, they have different soil conditions and urban characteristics. While Binh Duong is known for industrial development, Ben Tre has strengths in agricultural production and ecotourism due to its contact with the sea and rivers. These two cities are, therefore, influenced by different migration patterns.

Ben Tre is on the path of development, with its strengths still in agriculture and handicrafts. Recently, Ben Tre has promoted accommodation services (home stays) due to advantages such as coconut specialities and the ecology of ponds, lakes, and rivers. However, in recent years, Ben Tre has been affected by saltwater intrusion and drought and unseasonal rains. This has seriously affected the productivity and quality of its agricultural produce, including pomelo and shrimp, two typical fruit and fishery products that contribute to the economic development of

local households. The decline in agricultural productivity leads to a decrease in incomes and affects the lives of farmers. This is also why local workers have to migrate to big cities to earn extra income:

> *…In the past, there were some households growing salt-affected pomelos and then switching to coconuts. Besides, I have to go to work in other jobs, but the income based on coconuts alone is not enough. So, some people also left to go to Ho Chi Minh City or Binh Duong to go to work…"* (No. 08).

In addition to its strengths in agriculture, Ben Tre is investing in industrial development. This is also a magnet for local labour in the context of climate change, helping people who cannot rely on agriculture to earn extra income without having to migrate to neighbouring areas or major cities:

> *…Now looking for a gardener, I can't find anyone anymore. They're all gone. They went to work at the company up here for a bit. Big companies in Chau Thanh Asia. Then in Chau Hung, there are also some big clam companies…"* (No. 05).

Climate change affects crop productivity and creates economic shortages. So, breadwinners face a choice between staying in the soil and being poor or finding a way out of the area to earn a living (Baronchelli and Ricciuti, 2022). The decision to migrate due to climate change is common in many previous studies in the Mekong Delta, in which Dong Thap and Ben Tre are often mentioned (Kim and Minh, 2017). The results of in-depth interviews in Ben Tre also show a similar situation when people have no other choice because the soil is already saline:

> *Sometimes there are people who leave their land vacant because of saltwater intrusion, and next year they rent it out and do not work anymore…"* (No. 07).

Recent studies show that people who migrate from the Mekong Delta to Ho Chi Minh City due to climate change increase their earnings (Ngo, Vo, Ebi, and Hagopian, 2020). Ben Tre is close to Ho Chi Minh City, which has good career opportunities. Therefore, in the context of climate change, income from agriculture does not bring enough money for family expenses. This forces people to emigrate to improve their living standards:

> *… have to work another job, but the income based on coconuts alone is not enough, so some of them left to go to Ho Chi Minh City and Binh Duong to work."*

Migration as climate change adaptation can be analysed from both micro and macro perspectives. From a micro perspective, individuals or families want to migrate to find a better livelihood because there are problems with living conditions and crop failures in their place of departure. This is a "powerful reform" for survival, especially for large families (Nguyen and Sean, 2021). People in Ben Tre, when affected by climate change, also face the same situation. However, in Ben Tre now, there are many factories and enterprises appearing and attracting local people. Therefore, even though they cannot work in agriculture due to climate change, they can still apply for jobs without leaving home:

> *If there are not many companies here, there is definitely hunger and poverty here, because there is nothing to live on, there is a house with five or six people and people have little public land, how can people live?"* (No. 05).

In contrast, Binh Duong attracts labour for industry. Factories and enterprises there have a high demand for unskilled workers. For this reason, Binh Duong has become a magnet for immigrants from many areas:

> *Almost all migrants, there are also very few in the locality, 80* percent *are migrants from the central region and other provinces."* (No. 14).

Three types of natural disaster – floods, droughts, and storms – are often a driving force for migration (Berlemann and Xuyen, 2020). However, in Binh Duong, these disasters do not affect migration. Migration almost exclusively occurs through resettlement activities due to industrial development needs, not climate change:

> *…If someone is called an immigrant in the province, they are usually not. Only those areas that plan to become industrial zones, the people living there have to move. It's true that there are immigrants but it's because they are compensated to move to the resettlement area, or they have money and then they go to buy another place where they live..."* (Excerpt from No. 17).

In general, between the two cities of Ben Tre and Binh Duong, migration due to climate change is more pronounced in Ben Tre. Both cities have push and pull factors (Tataru, 2019:14). In short, if Ben Tre is characterised by forced migration due to poor quality of life, underemployment, drought, and salinity; the development of industry in Binh Duong has attracted people to build a better life there. At the same time, in Ben Tre, there are also cases of migration and job change to help improve incomes. The case for career improvement could be a move to coconut farming or a move into the industrial workforce.

### *d. Livelihood support policies*

The Vietnamese central government has set up the strategic Mekong Delta Plan (MDP) which includes transformations of livelihood models in adaptation to climate change. As the MDP does not prescribe detailed livelihood models, each local government can translate

the goals set in the MDP into its local development plans (Hong Quan Nguyen et al, 2019). Ben Tre is a coastal province in the Mekong Delta vulnerable to climate change, especially sea level rise and associated saltwater intrusion (Renaud et al. 2014). As such, the province is currently seeking to transform agriculture to adapt to these issues. Agricultural livelihoods in the province are diverse and favorable to the agro-ecological environment. The local government encourages rice farmers to diversify their crops instead of requiring them solely to cultivate rice. The Provincial People's Committee Action Plan for 2021 – 2030 to provide livelihoods support policies includes building irrigation works, freshwater reservoirs and supply clean water. Initiatives include the Ben Tre Water Management project; the Ben Tre South and North Irrigation System installation project; the Cu Lao Minh domestic water supply project in Thanh Phu, Mo Cay Nam, and Mo Cay Bac districts; and the construction of a water supply system from upstream of the Tien river to Ben Tre province (Natural Resources and Environment Newspaper, 2021). One commune official described in details the support:

> *There is a financial support policy for these activities. Those are support policies from the state. For example, they will provide support per acre of land. In addition, the local government also gives money for water storage." (No. 13).*

In addition to provision of financial support, the government supplies free fresh water to the people in the affected areas as one official stated: "The state brings fresh water to the people for free use. In the year of 2019 -2020 when there was a severe salinity intrusion, they supported water purifiers to the people".

In addition to infrastructure works, the province will support farmers to adjust cropping schedule suitable for each ecological sub-region, foster adaptive models of cultivation, husbandry, and aquaculture (fresh, brackish, salty water). At the same time, the province will implement disease prevention and strengthen the resilience of crops and livestock to climate change, combine the development and application of high technology in agricultural cultivation and aquaculture, and develop smart agricultural value chains that adapt to climate change (Ethnic Minority and Mountainous Area Newspaper, 2021).

In the protection of coastal mangrove forests, the province is strengthening the management and protection of forests and improving their quality to enable them to adapt to changing climate conditions. It is also developing community-based, climate-change-adaptive farming models based on coastal mangrove ecosystems and building irrigation systems to prevent saltwater intrusion (Phuong Hien, 2021).

In Binh Duong, the local government has issued an Action Plan to respond to climate change for 2021-2030, with a vision to 2050. The goal is to improve the effectiveness of climate change response and adaptation. In particular, projects have been created to strengthen the resilience and improve the adaptive capacity of communities, economic sectors, and ecosystems. This is to be achieved through investment and upgrading works to prevent and respond to climate change in different sectors; raising awareness and building capacity on climate change response; researching and developing new and advanced technologies in climate change adaptation; reducing GHG emissions; conserving existing forest areas, and; improving the forest coverage ratio to enhance the ability to absorb GHGs.

With a vision to 2050, the province will integrate "climate change" in all socio-economic programmes, plans, and strategies. This is intended to realise the goals of sustainable development and climate change resilience, the conservation of biodiversity and natural ecosystems, and enhanced community participation in biodiversity conservation and natural ecosystems.

### 2. Infrastructure and transportation planning

Development of infrastructure is a technical aspect of urban transformation. This transformation is reflected in the development of engineering works to adapt and withstand the impacts of climate change.

#### *a. Transformation in infrastructure*

Cities in areas heavily affected by climate change have a budget to improve the resilience of their local infrastructure. This includes systems for water and sanitation alongside energy and transportation to cope with problems arising from climate change.

*Improving resilience by developing infrastructure to upgrade existing environmental sanitation.* In the past, building infrastructure was in the annual plans of all localities. Where there is a requirement to integrate climate change into infrastructure development, infrastructure is still developed with the aim of improving the existing status and better preparing for future problems. The resilience to climate change is more evident in some infrastructure works in areas heavily affected by extreme weather. However, "robust and reliable infrastructure is particularly important for climate-related risk management. Infrastructure such as urban water supply systems are very vulnerable to sea level rises and reduced rainfall, especially in coastal areas; high population density and lack of infrastructure will be more vulnerable to climate change" (National Assembly, Committee for Science, Technology, and Environment, 2017).

The change in regulations on construction also shows changes in the direction of adaptation, making infrastructure more resilient to rising sea levels caused by climate change. The "National Technical Regulation on Construction Planning" (QCVN 01:2021/BXD, issued together with Circular 01/2021/TT-BXD in May 2021) stipulates the calculation of ground elevation with construction works. It states: "The minimum controlling ground elevation of the construction area must be 0.3 m higher than the calculated flood water level for civil land and 0.5 m for industrial land". It goes on to state that: "The areas affected by climate change and sea level rise, the control base elevation must be tested for its ability to cope with national climate change and sea level rise scenarios", and further that: "Planning of surface water drainage system must take into account the mitigating damage caused by impacts of natural disasters (floods, storms, high tides, slips, landslides), and responding to climate change and sea level rise".

In line with the climate change situation in Binh Duong, infrastructure projects that integrate climate change factors focus mainly on the drainage system and wastewater treatment, the rehabilitation and dredging of canals, and supplying clean water. These are followed by projects on flood control, GHG reduction, and road improvement. These projects mainly serve infrastructure improvement and urban environmental sanitation, with climate change response being included as a dual goal. For instance, infrastructure projects have been approved in Binh Duong's plan for the periods 2013 - 2015, 2016 - 2020, and 2021 – 2030. These focus on 50 projects, including drainage and wastewater treatment - collection (five projects); tidal - sluice control at the Binh Nham canal, Ba Lua - Vam Bung (two projects); urban flood control - urban drainage improvement (seven projects); improving embankments and upgrading the drainage capacity of canals, rivers, and streams (12 projects); projects on clean water (14 projects); traffic (six projects); a waste treatment complex (one project), and; upgrading rain and water level stations (one project).

In the last two decades, Ben Tre has implemented activities to respond to climate change, partly because it is an area vulnerable to extreme weather events. For this reason, Ben Tre is home to many national and international programmes on climate change. These actions aim to strengthen the resilience of communities, economic sectors, and ecosystems while also increasing proactiveness in responding to and minimising the damage from extreme weather events caused by climate change.

Regarding the transformation of infrastructure, Ben Tre has implemented effective projects in the past. These include the Ba Lai sluice gate, a dike to prevent saline intrusion, and a water supply plant. At present, projects to improve the resilience of ecosystems (in terms of physical infrastructure and natural ecosystems) are being implemented. These include sluices to prevent salinity at estuaries (one project); irrigation (two projects); fresh water supply (five projects); urban rainwater storage (one project); afforestation and biodiversity conservation areas (two projects); salinity monitoring in the environment (two projects); upgrading roads in areas at risk of landslides (one project); building dikes to prevent salt water from coastal Binh Dai - Ba Tri - Thanh Phu (one project); building urban areas - residential arrangement, wastewater collection and treatment, and building improvements (nine projects); garbage treatment (three projects), and; transportation development – bus networks and other projects.

In medium-sized cities, there has been a significant shift in infrastructure investment to deal with problems arising from urbanisation and the development needs of cities. These mostly relate to the quality of urban infrastructure and sanitation in general such as water supply and drainage systems, water level forecasting, canal reinforcement, wastewater treatment, waste treatment, the rehabilitation of roads to prevent congestion, urban greenery, etc. When these systems are improved, they contribute to improving the quality of infrastructure and reducing environmental pollution. In addition to these projects, building a system of dikes/dams/sluices to prevent high tides and salinity (such as in Ben Tre), water supply and clean water storage points, and infrastructure for renewable energy production are all infrastructure investments directly related to improving climate change resilience for cities. Although it is necessary to have specific evaluations, infrastructure works in general and transportation projects in particular have shown their effectiveness in dealing with climate change. Managers and local residents alike have commented on the positive changes of these projects.

The effectiveness of infrastructure works to prevent saline intrusion:

> *Here, the river water is always spread like that, only when the sea level rises, it causes a lot of salinity. For example, when the sea level rises late, then it rains, it will not be salty anymore. The dam on the Ba Lai River is to prevent salt water from coming here for decades. But now, you know why, the salty water of the Tien River, every year, it steps on the Chau Thanh area above. In Binh Dai, the problem of saltwater is already stable. In the past, because of the strong influence, the coconut here was very bad. Lately, Binh Dai's coconut was ranked first in the province because it was able to prevent saltiness." (Mr. P, commune officer of Chau Hung, Binh Dai, Ben Tre).*

***Upgrading flooded roads in the locality***:

> *Upgrading roads can also be done, because heavy rain is not able to escape in time, it is overflowing on the road, with additional culverts and dredging regularly. In the past, this was some fields, so rain would seep into the ground, but now people make the road surface with concrete and higher ground for their trading, so the water can no longer seep down, so the rain is overflowing onto the road. It's flooded, more than in the past." (Ms. C, small trader, Thuan An, Binh Duong).*

However, investment in good infrastructure always requires a large budget, which is also a limitation for some medium-sized cities. Infrastructure works play an important role in demonstrating the capacity of an urban area. This is especially true of large infrastructure projects such as dikes to prevent saline intrusion, coastal roads, ports, railways, metros, etc. In Ben Tre, large-scale infrastructure projects, in addition to local budgets, also need funding from central government, loans, international grants and funds, and capital from financial institutions and entrepreneurs.

### *b. Improving the transport system*

In terms of traffic, transformation is reflected in two groups of activities: (1) Improving roads to adapt to the rise of high tides, and (2) shifting means of transport towards "reducing GHG emissions" contributing to climate change mitigation (high GHGs are considered one of the causes leading to climate change).

In urban areas, for the change of transport infrastructure in the context of rising sea levels, elevating roads is sometimes also applied in areas with high tides. This is a short-term solution that has not proven long-term effectiveness. Some roads in flood-prone areas due to high tides have also been improved. However, this can lead to local flooding in other areas. In addition, in medium-sized cities, raising the level of roads also faces financial problems: "The selection of the ground level in construction is also a difficult problem with the balance between the requirements for flood control, safety for people, and urban activities with the ability and financial condition of the city as well as investors and residents" (Journal of Construction Planning, No. 88/2017).

The construction and improvement of roads shows that the development of transport is largely driven by the need for urban infrastructure development, while the response to climate change is only one criterion. In medium-sized cities in Vietnam, urbanisation is still ongoing, and the construction and renovation of urban transport systems is part of the annual plan of provinces. For some cities clearly affected by climate change, the transformation taking place aims to make transport systems more resilient to climate change and use them to prevent its effects. This is evident through the upgrading of roads to resist the impact of high tides, landslides, and rising water levels.

Besides the development of infrastructure, the reduction of GHGs is also a change in the transport industry. In urban areas, traffic activities increase with economic development. Energy use and GHG emissions in transport are calculated to increase by 80 percent by 2030 (MONRE, 2020). Meanwhile, the transport sector contributes to total GHG emissions in Vietnam, accounting for 18 percent of total CO2 emissions in 2014 (NDC Partnership,


*The slogan "New rural development, new dynamism, new look" in the newly developed urban area, photo by Phan My Lien*

WB, GIZ, 2019). Some solutions to reduce GHG emissions from traffic are the development of public transport (bus, BRT, metro); using clean fuel; increasing the proportion of electric and hydrogen vehicles; implementing fuel consumption standards and emission norms; and shifting from road transport to water and rail (Decision 896/QD-TTg).

Among the climate change mitigation solutions for the transport system, public transport not only helps to reduce GHG emissions but also to achieve other social goals. Public transport development requirements are specified in the development planning of urban areas (grade III and above). Investing in the public transport system not only has environmental but also social benefits. It allows "low-income people to use it to access employment opportunities, or facilitate mobility benefits for special groups who may have mobility or safety problems" (Diane Archer and Charlotte Adelina, SEI Asia, 2020). In general, according to the Department of Environment, from 2012 – 2018, the number of buses increased every year in Vietnam, with a particular increase in vehicles using compressed natural gas (CNG) fuel.

**Table 1. Number of buses in Vietnam from 2012 to 2018**

*Source: Report of the Department of Environment, led by research on the Development of Electric Vehicles in Vietnam, Transport Initiative in NDC for Asian Countries (NDC-TIA), 2021.*

| Year | Number of buses using Diesel and CNG | | Total |
|---|---|---|---|
| | Diesel | CNG | |
| 2012 | 8,403 | 82 | 8,485 |
| 2015 | 9,554 | 145 | 9,699 |
| 2018 | 11,616 | 435 | 12,053 |
| Number of increments | 0.38 times | 4.3 times | 0.42 times |

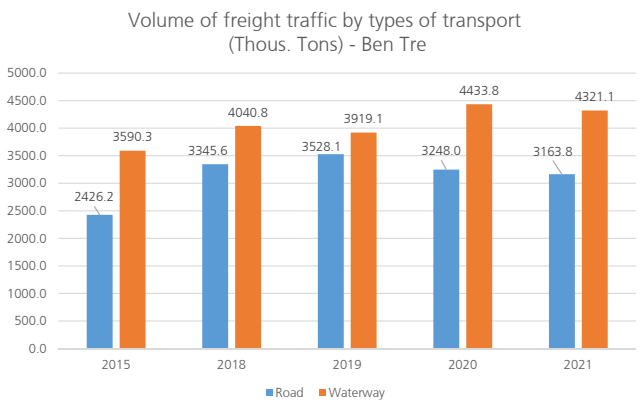
In general, the characteristics of provincial traffic transformation are also reflected in the development of climate-change-responsive transport systems in Binh Duong and Ben Tre. In Binh Duong, climate change is not often visible. Therefore, the transport development policy integrating climate change (Decision 430/QD-UBND, 8/2/2021) focuses on solving problems of the current urban transport system. As such, it includes projects such as: "Building an Intelligent Urban Traffic Management System" and "Road Improvements to Solve Traffic Congestion".

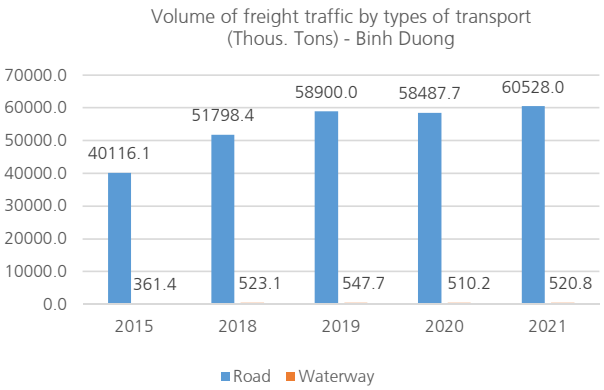
On the other hand, Ben Tre is implementing traffic projects to adapt to climate change in the 2021 – 2030 period. These include "Upgrading, Renovating, and Constructing Roads and Waterways in Areas often Threatened by Landslides, High Tides, and Sea Level Rise"; the construction of a dike to prevent saline intrusion combined with roads connecting the coastal districts of Binh Dai - Ba Tri - and Thanh Phu (2nd phase); and the "Development of Infrastructure, Bus Network" project in Ben Tre. There is also a region-wide project: "The Coastal Road of Tien Giang - Ben Tre - Tra Vinh".

Ben Tre also has a waterway transport network. This is an important channel in domestic freight transport (freight in Binh Duong moves mainly by road). Ben Tre has started to develop four seaports: Giao Long, Ham Luong, Thanh Phu, and Binh Dai. This is the first step in the development of maritime transport. However, due to its topography and hydrology, the Mekong Delta does not have a deep-water port. Therefore, maritime transport has not played a major role in the economy in general and adaptation to climate change in particular. In future, water transportation is also considered as one of the transformations to adapt to climate change and reduce GHG emissions.

**Figure 5. Volume freight traffic by types of transport in Ben Tre and Binh Duong**

*Source: Vietnam Statistical Yearbook, 2021*



Regarding the effectiveness of the development of public transport systems and the use of clean fuel, most provinces and cities have invested in buses and encouraged people to use them. However, in medium-sized cities, public transport is not a priority for many people, including those on low incomes.

> *Currently, we mainly travel by motorbike. If you go nearby, you can walk or bike, go to the market by motorbike. Travel by bus is very rare. If you go as far as Binh Dai, taking the bus is cheaper and more convenient." (Ms. V, farmer, Chau Thanh, Ben Tre).*

Motorbikes remain the most popular form of transportation (there were 58.2 million registered motorbikes in 2018, accounting for about 92 percent of vehicles in Vietnam, according to the Institute of Strategic Planning & Transport Development, 2018). While, regarding the use of clean fuel, according to Vietnam Register, the number of electric vehicles (EVs) (hybrids, plug-in hybrids, and pure EVs) in Vietnam is still low. In 2019, there were only 140 EVs, 900 more by 2020, and 600 more by the end of the first quarter of 2021. Of these, battery-powered transportation accounts for a very small percentage.[8]

In this respect, the change in means of transportation is not directly related to the adaptation or improvement of resilience to climate change, especially from the citizen's side. Their choice largely depends on the convenience and economy of transport. Even the choice of fuel for vehicles, using those which reduce GHGs first, comes from the economic purpose of the user and then combines with the purposes of environmental protection. However, media messages also have a certain effect in changing people's awareness and habits about environmental protection and climate change.

> *Because if I learn about electric motorbikes, I can only charge five thousand for electricity and use for 40 km. I changed the battery and it cost me only five or six thousand to charge, I think it's too reasonable. Because this is modern and economical. If it's true that I ride an electric motorbike that I say is modern, because I ride it, I feel very trendy. After using an electric motorbike, I feel that vehicles on the road are very noisy and emit a lot of smoke, but my motorbike does not emit any smoke." (Ms. M, entrepreneur, Ben Tre City).*

It is similar when they choose clean fuel:

> *For example, the car you drive is filled with unleaded or low-lead gasoline, which means that its quality is high, its cost is high, by yourself. Because it has so many things, I use it in the form of savings, I protect the environment, I also reduce my costs. This saving is compared to the efficiency brought, not the savings that we undercut. The same goes for gasoline, if I use a good one, my machinery will not wear out. But that is usually associated with two factors that are between the benefits and the environmental protection." (Ms. D, enterprise, Binh Duong).*

Among population groups, the entrepreneur group is obligated to comply with environmental and climate regulations in freight transport activities. However, these regulations are not implemented strictly.

> *The freight transport is not very strict, delivery trucks on the road only have to comply with the regulations on transportation. For such environmental control, on-site transportation will be more strictly controlled than this long-distance transport." (Ms. L, enterprise, Thuan An, Binh Duong).*

### 3. Energy transformations

The energy transition has been defined as a process from poor to modern fuel (Gerald Leach, 1992). It is also commonly understood as a shift from traditional energy (coal and biomass) to low-carbon energy sources (cleaner energy such as electricity) (Berkkhout et al., 2012). The energy transition begins with agricultural residues such as straw, sugarcane, maize, hemp, fruit tree branches, and firewood. It then moves to natural resources such as charcoal, before moving again to fossil fuels such as petroleum, gas, and electricity. Finally, it moves to renewable energy. Moreover, electricity plays an important role in economic growth (Halkos, 2017) and Vietnam is not out on that track.

#### *a. Electrification*

Vietnam's economy is considered one of the fastest-growing in the world with a very high rate of growth in foreign direct investment (FDI report, 2021). Annual gross domestic product (GDP) growth was about 7 percent between 2004 and 2019 (World Bank, 2022). When the Vietnamese economy became strong enough, in 2008, 95 percent of rural households gained access to electricity (Khandker et al., 2013). This rate increased from 97.31 percent in 2010 to 100 percent of communes, 99.30 percent of rural households, and 11/12 island districts in 2020 (EVN annual report, 2021). Similarly, a study of the energy transition in Vietnam from 2004 - 2016 (Trung Thanh Nguyen et al., 2019) showed that Vietnamese households are moving from traditional energy sources (coal and biomass) to modern sources (oil, gas, and electricity). This matches our own findings in Ben Tre and Binh Duong. All cases confirmed that they mainly use national electricity sources, likely use diesel oil for electricity generators during temporary power-cuts, and daily use gasoline for their vehicles. In Binh Duong, factories have shifted to integrate solar energy with the national grid to meet the sustainable development goal

8 https://tapchicokhi.com.vn/post/thuc-trang-thi-truong-xe-dien-viet-nam

(Table 2). However, energy prices do not comfort all public sectors and supply services are inadequate. These two limitations are also pointed out by fruit tree farmers, fruit trade enterprises in Ben Tre, and poultry farms in Binh Duong. Because these limitations come from only one government-owned energy supplier, households must find their own ways to adapt to high costs and insufficient supply. This can be done by reducing three phases to a medium of two phases or even low-voltage on one phase to minimise machine use and share power with neighbours who need energy to light their houses or farms. Those farmers also use oil to run electricity generators to ensure farming can continue during a temporary power cut (Table 3). This adaptive action is also mentioned in the theory of the energy ladder model (Hosier and Dowd, 1987). This model is based on the consumer theory that, when income rises or falls, households consume more or less of the same goods and shift to higher or lower quality goods. For instance, some poor families in Ba Tri commune, Ben Tre province saved by using firewood to cook and minimised their spending on lights (Ben Tre resident's answer). Those cases show that the need for more choices in energy sources is necessary to avoid an increasing burden for poor households such as attracting private investors to produce clean energy.

> *Electricity in this rural area is used less often. The poor don't dare to use much. The Government has a reward programme for households who have a bill of less than 100,000 VND/quarter. They turn on electric lights late at about 19:00-20:00 and go to bed early to save and use firewood for daily cooking. I do shrimp agriculture. Electricity price for production is 3,000 VND - double the lighting price." (Shrimp farmers talking about their neighbours).*

### *b. Renewable energy*

The energy transition is also well-known as the process to replace current energy sources with renewables. However, many countries have shown that the transition of energy does not need to jump from one source to another. The transition will depend on the available energy sources and be influenced by various socio-economic factors (Mensah and Adu, 2015).

Vietnam currently produces and uses a mix of gas, oil, coal, hydropower, and renewable energy. The most available and abundant renewable sources are solar and wind due to the long hours of sunshine with a long dry period each year. With sufficient renewable sources so readily available, the Vietnamese Government has put strong efforts into meeting the country's energy needs through alternative power, reflected in National Energy Planning and the National Power Development Plan 7 (MOIT and DEA, 2017). Since 2015, 47 solar energy power stations have been built with a capacity of 2,300 MW, connected to the national electric grid in all the regions of the country. As such, the renewable energy targets were set for a power generation capacity of 12.5 percent by 2025, a target which was surpassed. According to the 2021 EVN annual report, the capacity of renewable energy – including solar, wind, and solar rooftop – was around 10 percent in 2019. This increased to 25 percent in 2020. This growth showed a positive perspective of the energy transition. However, if we look into the ratio of production and purchase percentage of solar energy, for instance, it was only 5 percent out of 12.8 percent in its capacity. This means the development of renewable energy continues to face challenges. The four main barriers are: institutional, financial, technical, and information (MOIT and DEA, 2017; Vieweg et al., 2017; Shem, C. et al., 2019).

In the public sector, information and technology are likely to be the main issues in the small-scale cities of Ben Tre and Binh Duong. Solar energy is not far from public consciousness. All cases in these cities had a good response to the solar energy concept. However, only about one-third showed willingness to shift to this green energy source. The main reason for this is the high investment risks and the lack of technical knowledge. For instance, renewable energy LED lights are for households only (No. 06, Table 2) or installation is too complicated to be ready to use (No. 19, Table 3). According to the survey in the cities, solar energy has not been used widely among farmers and small enterprises in Ben Tre. However, it has been commonly used for about two years among industrial sectors. Even so, the production rate of renewable energy contains very little in the total energy consumption and remains far from the target of a low-carbon transition in 2045.

**Table 2. Findings on the current usage of energy and the status of shifting to solar energy (the case of four communes (Binh Dai, Cho Lach, Ba Tri, and Chau Thanh), Ben Tre City, and Ben Tre province)**

| Ben Tre | Climate change impacts | Purposes of using current energy | Will you shift to new energy? Why? |
|---|---|---|---|
| Seafood farmers + traders (shrimp, lobster, crab and oyster) (No. 01, 02, 03, 10) | Heavy rain in a short time (No. 01) | Mainly use three phases of electricity for aquaculture farming such as aeration, feeding, and aqua-waste discharge. (No. 01, 02, 03, 10)<br><br>Electric generators run by diesel fuel for the seasonal power-cut plans (No. 02, 03) | Yes, because of being able to save on electricity bills monthly and even to sell for neighbours or EVN but waiting for approval in large-scale farming (No. 02)<br><br>No, because of the non-usage of feeding machines in small-scale farming (No. 03) |
| Fruit tree farmers (coconut, orange, and pomelo) (No. 05, 08, 11, 12) | Freshwater shortage and salinity (No. 05) | Mainly use three phases of electricity for watering, fertilising, and planting in fruit tree farming (No. 05, 08, 11, 12)<br><br>No spare electric generators because of a flexible watering schedule (No. 05, 08, 11, 12) | No, because of adequate national electricity supply and the high cost of solar energy installation (No. 05, 08, 11) |
| Flower farmers (No. 07) | Strong heat and freshwater shortage | Mainly use three phases of electricity for watering, fertilising, and planting in flower farming (No. 07)<br><br>Cooling storage by fans or air-conditioners (No. 07) | Maybe, having seen neighbours using it efficiently (No. 07) |
| Communal officers (No. 04, 06) | Salinity, heavy rain, strong heat (No. 04) | 99 percent of households have electricity, not yet solar or wind energy (No. 04)<br><br>Street lights are also from the grid (No. 04)<br><br>More households use fans and air-conditioners because of the strong heat (No. 06) | Solar/wind energy programme is heard for coastal communes like Binh Dai (No. 04)<br><br>No, solar energy is in light only (No. 06) |
| Fruit trader (pomelo and coconut) (No. 13) | Strong heat and salinity | My workshop uses three phases of electricity. Two years ago, I registered to install solar panels and am still waiting for approval (No. 13) | Ready to invest because of profit and being able to be independent in terms of energy supply (No. 13) |
| Garment worker (No. 09) | Strong heat | My factory used electricity and has shifted to solar energy for four months. My home uses electricity for lights and fans (No. 09) | |

**Table 3. Findings on the current usage of energy and the status of shifting to solar energy (the case of two communes (Thuan An and Ben Cat) in Binh Duong province)**

| Binh Duong | Climate change impacts | Purposes of using current energy | Are there any profits after shifting to solar energy? Any saving activities? |
|---|---|---|---|
| Carton paper manager<br><br>(No. 14) | Strong heat | Integrate national electricity and solar energy for production (No. 14) | Don't know because the company used it two years ago at the request of the industrial management board (No. 14) |
| Workers<br><br>(No. 15, 16)<br><br>Labour union members (No. 21) | None/normal (No. 15, 16)<br><br>Strong heat (No. 21) | I know the company is using solar energy and also electricity (No. 15, 16)<br><br>My company uses only national electricity. Others may use I am not sure (No. 21) | Saving electricity is one of the regulations, for instance, turn off lights before leaving (No. 15) |
| Garment managers and workers (No. 20, 22) | Strong heat (No. 20, 22) | Use electricity only, not yet shifted to solar energy for production but use for warming water (No. 20)<br><br>Solar use for steam boiler only<br><br>Change all lights to LED (No. 22) | Yes, will install solar panels in the future to save electricity costs (No. 20)<br><br>In fact, this is the new trend to move to solar energy and EVN will not buy electricity from us. |
| Poultry farm (chicken) managers (No. 23) | Strong heat | Use electricity only, not yet shifted to solar energy for farming. Use lights with little panels for lighting gardens only (No. 23)<br><br>Use electricity generators in case of power cuts (No. 23) | I want to have different energy but there is a rubber farm surrounding me which causes too much shadow for solar energy (No. 23) |
| Poultry farm (pig) managers (No. 19) | Not mentioned | Use electricity only, not yet shifted to solar energy for farming because of complicated technology<br><br>Use solar for hot water at home (No. 19) | No profit. The investment in solar is high and technology is difficult (No. 19) |
| Small-scale trader (No. 18) | Not mentioned | Use three phases of electricity to run the freezer for cream cakes.<br><br>Use the electricity generator to ensure the freezer works continuously (No. 18) | Maybe but I don't know how. I have heard the first investment in solar energy is high (No. 18) |

### *c. Green consumption*

Green consumption is defined as consuming environmental products with a high awareness of environmental protection (Lee, 2010). Meanwhile, consumer behaviour is understood as a group of actions including seeking information, making decisions, buying, using, disposing, and recycling products, services, and experiences (Keller and Kotler, 2011). Green consumption is not only consuming green products but also minimising the risks to the environment. However, the research on green consumption and its influencing factors shows that attitude, knowledge, price, and trends will control the consumption intention of Vietnamese consumers to purchase green products (Luong H.T et al., 2021). This finding is not far from our survey results under the

context of energy transition in Ben Tre and Binh Duong. Of the four influential factors on consumption intention, price and trends are the two main correlations. Most of the farmers' responses showed their willingness to shift to solar energy after they understood that the price to invest in installation is reasonable or they could see the profit of their neighbour's system. On the other hand, smaller-scale farmers in Ben Tre and poultry farmers in Binh Duong are not willing to pay for solar panel installation because of the high investment required. In Vietnamese society, people live in their communities and their decisions are strongly influenced by other relationships. Therefore, the price and the trend of moving to new energy sources are linked.

A limitation of our survey is a lack of data on the consumption of household appliances and the transition from high-carbon-emission to low-carbon-emission products. Some responses showed that the use of household appliances such as fans and air-conditioners is growing rapidly. The reason is mainly the strong heat and long dry season rather than a lack of awareness of green consumption. A lack of information on environmentally-friendly products made data on green consumption weak.

### *d. Policy implementation*

The Vietnamese Government has launched a National Action Plan (NAP) to implement the Agenda for Climate Change Adaptation 2021 - 2030 and vision to 2050. Following this strategy, Ben Tre and Binh Duong started to implement the NAP by listing 53 projects (Binh Duong) and 103 projects (Ben Tre) that will be carried out and completed by 2030 at the latest. However, there are some policy and cost-benefit-related issues when implementing energy conversion programs.

> *My house is using a lot of electricity so I want to change to solar energy… Nearby, there is a range of houses for rent. They use solar energy. I intend to ask for advice and will do the same for my house, the price is about 170 million dong" (Seafood traders in Ben Tre, No. 02). "I went to some energy conferences and also asked somebody who knows about the operation of solar energy. Sounds interesting. I asked many times and calculated the cost and benefit. Finally, no, I can't make it." (Poultry farm in Binh Duong, No. 19).*

**Table 4. Recommendations on energy from residents in Ben Tre and Binh Duong**

| Ben Tre | Energy saving activities | Climate change adaptation activities |
|---|---|---|
| Seafood farmers + traders (shrimp, lobster, crab, and oyster) (No. 01, 02, 03, 10) | Share electricity from the standard power source with neighbours by lowering the voltages (No. 02, 03)<br><br>Spare electricity generation machine for aqua-waste treatment or for power-cuts (No. 02) | Willing to invest in solar energy but waiting for local government approval in large-scale farming (No. 02)<br><br>Not willing to invest in solar energy because of the small-scale farming and non-usage of feeding machines (No. 03) |
| Fruit tree farmers (coconut, orange, and pomelo) (No. 05, 08, 11, 12) | Share electricity from the standard power source with neighbours by lowering the phases (No. 05, 08)<br><br>The heat is strong at 13:00. Before, I could use a hand fan. Now, I must use air-conditioners and electric fans. The electricity bill has doubled (No. 08, 11, 12)<br><br>I reused water after cooking or washing for watering trees (No. 05) | Store rainwater for home usage during a high salinity period not for farming (No. 08, 11)<br><br>Dig shallow wells and share with neighbours during the salinity season<br><br>Share freshwater bought from neighbouring provinces (No. 11)<br><br>Use water hyacinths to keep the moisture in the soil above the root tree (No. 08, 11)<br><br>Shift types of tree (pomelo/orange instead of coconut) or intercrop pomelo with coconut (No. 11)<br><br>Increase the height of the roof to cool the house (No. 08) |

| Ben Tre | Energy saving activities | Climate change adaptation activities |
|---|---|---|
| Flower farmers (No. 07) | Install ventilation fan<br><br>Apply fabric covers to reduce the heat and distribute the sunlight for flower farming | Increase the height of the roof and use cooling material for the warehouse roof<br><br>Shift the schedule of watering to very early morning and late afternoon<br><br>Wear more clothes to work at noon time |
| Communal officers (No. 04, 06) | Because of the hot weather, people use more fans and air-conditioners (No. 06) | Households drilled a shallow well above 10 meters or 500 meters if they have money. Others will buy water for valuable fruit or sensitive flowers. Some large farms buy water with a total cost of up to several billion dong (No. 06) |
| Fruit trader (pomelo and coconut) (No. 13) | No information | I studied to reuse coconut skin to make a coconut net which is useful and friendly |
| **Binh Duong** | | |
| Workers<br><br>(No. 15, 16)<br><br>Labour union members (No. 21) | Saving electricity is the main strategy of the company. There is a warning penalty for somebody who forgets to turn off the lights (No. 15) | Educating workers on environmental protection such as planting trees, cleaning and sorting urban waste, and minimum usage of electricity (No. 21) |
| Garment managers and workers (No. 20, 22) | I tend to study solar energy to save electricity (No. 20) | |
| Poultry farm (pig) managers (No.19) | The leader plays an important role to remind employees to save energy such as turning off electrical devices when needed, reusing papers, and using proper water amounts | |

# VI. POLICY IMPLICATIONS

*Ben Tre river, photo by Phan My Lien*

This research will propose recommendations for policies that will, hopefully, contribute to more effective climate resilience strategies.

Policies to help farmers and enterprises cope with climate change: Local authorities have introduced quite a few policies to support people affected by climate change. These policies aim to provide those people (farmers and enterprises) with the capacity to be more resilient to the impact of climate change via training sessions and seminars as well as financial support for economic losses. However, these policies have only been conducted in a superficial manner and, therefore, have not proved effective. As a result, some farmers have had to handle the challenges caused by climate change alone. These are quite often poor people who cannot afford the transformation required and so have had to sell or abandon their land. Therefore, policies should be implemented more effectively so that the people affected are capable of adapting to climate change and are more resilient to its impact. In particular, greater attention should be paid to poor farmers who are unable to invest in new farming practices due to a lack of knowledge, skills, and capital.

More precise weather forecasting can help local farmers cope more effectively with the changing climate. Therefore, policies should be oriented to improve weather forecasting to help farmers and enterprises, especially those living in vulnerable areas, to become more resilient and adapt to climate change. Meanwhile, hi-tech farming can help farmers adapt to climate change. However, this demands a lot of financial as well as human capital and rigorous training is necessary.

The vulnerability of regions should be continuously assessed and the need to build climate-resilient infrastructure to cope with flooding and extreme weather events should be identified. At the same time, it is also necessary to evaluate the effectiveness of climate-resilient infrastructure. Once an artificial infrastructural system is introduced, it may have adverse effects on neighbouring localities or the natural hydrogeological structure of an area, as is the case with urban road upgrades that often lead to flooding elsewhere.

Renewable energy has been developed in Vietnam over recent years. However, many shortcomings remain that must be addressed before renewables become popular and effective. To take advantage of this resource, energy

storage technologies such as solar energy storage batteries and small-scale wind energy development (on farms) should be developed. Meanwhile, energy infrastructure should be synchronised and the problem of integrating solar with the existing national grid power system needs to be solved. Moreover, the use of renewables is not widespread in households due to unsuitable costs. This is also an economic problem when using alternative forms of energy. In the future, renewable energy can be popularised through pilots in public buildings, offices, and factories.

Insurance for climate-change-related hazards has become part of the disaster risk-management financial system. This is recognised as part of a package of measures to respond to climate change, acknowledged in 2015 at the 21st UN Conference on Climate Change in Paris. Disaster-risk insurance for production, business activities, assets of enterprises, and society is included in the Vietnam National Strategy to respond to climate change. However, this is a solution for the distant future. Today, this programme is not widespread because climate change is a long process and its impacts are not as well defined as natural disasters or catastrophes. "Insurance is used to address impacts associated with extreme weather but is often not feasible for slow and predictable events or for high-probability processes under different climate change scenarios" (IPCC, 2012). Insurance also often involves the private sector. The Committee on Science, Technology, and Environment of the Vietnam National Assembly also states that, in responding to climate-change-related hazards in regions at increased risk, the private insurance system is a primary risk-management option. In particular, low-income groups need special assistance in risk management and adaptation. Therefore, policies to promote private insurance in issues regarding climate change should be promoted.

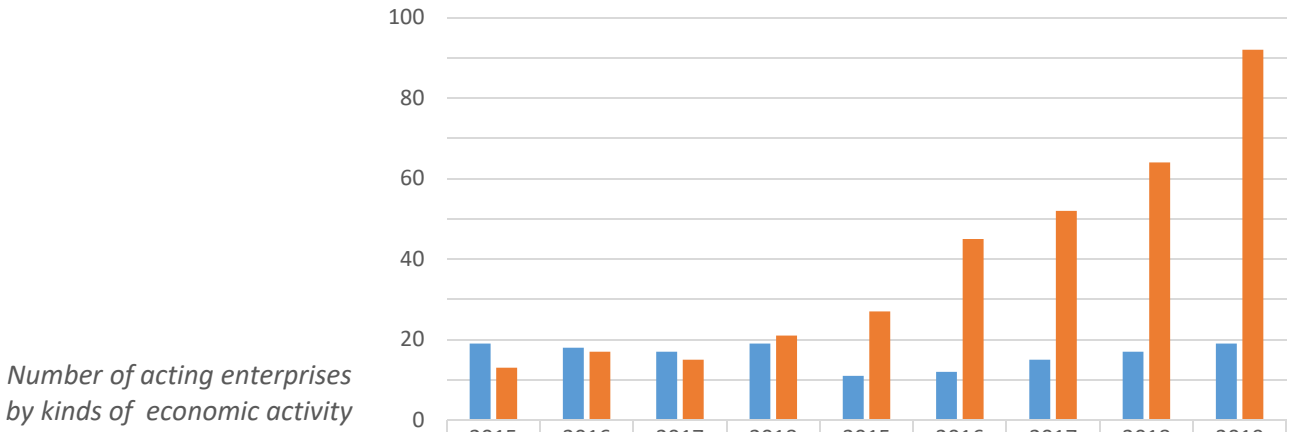
Participation should be promoted more effectively in the community's adaptation and resilience to climate change. As climate change is a complex issue, it requires the participation of many levels of management, different regions, and sectors (Leck and Simon, 2013) in the decision-making process, avoiding the exclusion of disadvantaged groups. In the report "The Programme of 100 Cities Responsive to Climate Change" (2017), the participation of people and organisations is considered an important element of adaptation. Adaptation to climate change in an urban area is the ability of individuals, communities, organisations, businesses, and systems to continue to exist, adapt, and develop despite the frequent pressures and significant fluctuations of climate change. A mechanism for participation is mentioned throughout government programmes in which communities participate and implement projects. The Vietnamese government also encourages the participation of different stakeholders and sectors in coping with climate change while treasuring the leading role of the state.

Local residents have participated in environmental protection and activities related to climate change response launched by local authorities, international projects, and local socio-economic organisations. However, this participation is still limited to the participants and must be through the activities of specific local projects. Citizens and entrepreneurs participate in seminars and training to raise awareness and update techniques related to the environment, climate change, and livelihood transformation. In provinces and cities heavily affected by climate change, such as Ben Tre, seminars and training activities have been organised more often and given higher budgets.

In Vietnam, the participation of the private sector in climate-change-related activities is being encouraged as stated: "Strengthening the adaptability of urban areas will require the active participation of the private sector" (National Assembly, Committee on Science, Technology, and Environment, 2017). Currently, for response to climate change, the private sector is often called upon to invest in areas such as waste treatment, renewable energy, green technology, high technology, health infrastructure, and insurance to cope with epidemics caused by climate change.

**Figure 6. The number of enterprises investing in electricity production, gas, steam conditioning, and water supply and drainage***

Source: Binh Duong Statistical Yearbook, 2020; Ben Tre Statistical Yearbook, 2019; *data is mainly private and foreign enterprises (SOEs account for only 0.17 percent in Binh Duong and 0.41 percent in Ben Tre).




| | Ben Tre | | | | Binh Duong | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Electricity, gas, steam and air conditioning supply | 19 | 18 | 17 | 19 | 11 | 12 | 15 | 17 | 19 |
| Water supply; sewerage, waste management and remediation activities | 13 | 17 | 15 | 21 | 27 | 45 | 52 | 64 | 92 |

### *Vulnerable groups and gender*

The groups vulnerable to climate change can be identified as those affected by extreme weather, especially the poor in areas hit by rising sea levels and extreme weather events. However, people living in areas affected by climate change appear to demonstrate certain adaptation to these changes, except for areas experiencing harsh phenomena such as soil erosion and landslides. For instance, in Ben Tre province, the city and towns are heavily affected by changes in weather and hydrology, although this impact can be mitigated to some degree. Meanwhile, in some areas of the Mekong Delta, people have lost their livelihoods and had to migrate elsewhere. In this light, state policies need to be divided into several levels of vulnerability in areas markedly affected by climate change, especially coastal areas and those with unusually higher-than-average temperatures. From that basis, different levels of support could be applied for vulnerable populations at each level.

From a gender perspective, gender equality is still mentioned as a key word in gender analysis. The impact of climate change may not have a clear delineation of vulnerability in respect of gender equality. Therefore, more specialised study is required. However, from the perspective of concern about and adaptation to climate change, gender shows some remarkable characteristics. For instance, in the same career, men clearly show more interest in weather issues and new technologies and actively seek information about these. On the other hand, from a consumption perspective, women are the group leading the trend. Therefore, depending on gender characteristics, there may be different strategies in improving people's capacity and attracting the participation of men and women in programmes of environmental protection, energy conversion, and sustainable development.

# CONCLUSION

Climate change has had negative impacts on Vietnam, one of the countries most heavily affected. In Chapter 1 of this report, the current status of climate change and its impact on Vietnam in general, and southern Vietnam in particular (Ben Tre and Binh Duong), is analysed.

While Chapter 2 provides only basic concepts, Chapter 3 focuses on presenting transformations in three dimensions: Livelihoods, infrastructure and transport planning, and energy. In terms of livelihoods, farmers have changed their agricultural practices from freshwater agriculture to brackish or saltwater agriculture or aquaculture. Some farmers have the capacity to invest in hi-tech farming. Meanwhile, others who do not have this capacity have to rent out their land, or give it up altogether and go to work for companies in the region. In addition, many farmers, especially young people, have left for big cities such as Ho Chi Minh City and Binh Duong in search of work. Businesses are also affected by the impacts of climate change. Many companies have less revenue, forcing them to diversify products and services to stay profitable.

In terms of infrastructure, the government has built a number of saline prevention works to limit the harmful effects of saltwater intrusion in areas vulnerable to climate change. The planning of infrastructure systems such as roads, water supply and drainage systems, anti-flood systems, and wastewater treatment all take climate change into account.

Regarding transportation, to cope with the impact of rising sea levels and flooding in urban areas, the road system has been enhanced and reinforced. Some policies, such as developing bus systems using clean fuel, increasing electric and hydrogen vehicles, fuel consumption and emissions standards, and diversifying transportation activities (such as river transport) have been implemented.

Regarding energy, people in the study area still use energy from gas, oil, coal, and renewable sources. However, people are gradually switching from traditional energy sources such as coal and firewood to modern energy sources such as oil, gas, and electricity. However, because there is only one power supplier, residents have to deal with electricity shortages as well as high electricity prices. Popular renewable energy sources are solar and wind. However, solar energy only accounts for a very small share of the energy market and its capacity has not yet fully been exploited. The development of renewable energy in Vietnam continues to face many institutional, financial, technical, and informational challenges.

Due to the impact of climate change, people use more appliances such as electric fans and air conditioners and, therefore, consume more electricity. The current cost of investing in solar energy is still high for low-income people, so the use of this energy source remains limited.

Although investment in infrastructure, transport, and energy systems and livelihood transformation projects has taken place, they remain limited in scale, investment capital, and efficiency in small and medium-sized cities.

In the final part of this report, policy recommendations were presented. These policy recommendations focus on effectively supporting people whose livelihoods are severely affected by climate change, especially vulnerable groups, so that they can transform their livelihoods without having to abandon their land and villages or fall into poverty and debt. State support is essential because livelihood transformation requires financial capital and skills. In addition, policies on weather forecasting, vulnerability, and needs assessments of people in this area, as well as an impact assessment of infrastructure works to help them cope with climate change, needs to be done.

Energy policies should focus on developing renewable energy storage systems and integrating electricity from renewable energy into the national electricity grid. Privatising the electricity supply, developing insurance policies for losses due to climate change, and encouraging community participation in adaptation policies and building resilience to climate change are also necessary.

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