



# Saltwater Intrusion - An Evident Impact of Climate Change in the MD and Propose Adaptable Solutions

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**Abstract:** Mekong Delta (MD) is the main rice growing area in Vietnam. However, it is facing with climate change including increasing temperature, drought, salinization during dry season and flood in rainy season. Salinization and drought have been seen very clearly in this region since late 2015 and early 2016. Many areas of rice and vegetables, fruit trees and seafood are lost, livelihood of many farmers are affected. Objectives of this study are to assess the impact of salinization in MD and to propose essential strategies in response to climate change by macro organizations and suggest alternative agricultural production systems adapted to climate change in order to help farmers and related agricultural agencies to apply for livelihood security of the rural population. This study paper applies the method of literature review, drawing remarks from a large set of data, documents and reports from research institutions and from research and development projects by non-governmental and governmental organizations. Moreover, the solutions are also based on directly interviewing farmers, relevant government officers, extension staffs, and companies and by directly observed the impact of climate change in the MD. The result displayed the impact of climate change in the MD clearly reflected by saltwater intrusion; the constraints and challenges caused by climate change in the agricultural production systems in the coastal provinces of MD, in details in the 3 ecological zones of fresh water, brackish water and saltwater; summary of strategic solutions and actions to adapt to climate change including an emphasis on opportunities and challenges for Vietnam's rice sector and finally proposed alternative agricultural systems to cope with adverse impacts of climate change in the MD. The author has proposed ten (10) alternative agricultural systems to help ensure the livelihood of the rural population in salinization affected areas.

**Keywords:** MD, Climate Change, Saltwater Intrusion, Agricultural Production Systems, Freshwater Zone, Brackish Water Zone, Saltwater Zone

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## 1. Introduction

Mekong River Delta (MD) has about 3.96 million hectares of land area excluding small islands, in which 2.60 million hectares accounting for 65% are used for agriculture and aquaculture. In regard to agricultural land, annual crops (more than 90% of rice) accounted for over 50%. Land for growing upland and cash crops is about 150,000 hectares, perennial crops being over 320,000 hectares, and about 8.2% being natural area. [1].

Soil groups in MD are diversified for agricultural development. Alluvial soil accounts for about 29.7% of the region's natural land, and about 1/3 of the country alluvial soil. This soil is suitable for crops such as rice, fruits,

vegetables, and short-term industrial trees. Alkaline soil accounts for about 1.2 million ha (40%) throughout the region. Gray soil occupies about 3.4% of MD; besides, there are some other types of soil such as sandy soil, peat, red and yellow soil, which is occupying an insignificant area of about 0.9%. In general, the soil here is very favorable for crops such as rice, coconut trees, sugarcanes, pineapples, and other fruit trees. This region possesses a long coastline of 732km with many estuaries and bays. Sea in this region contains many valuable marine creatures in large reserves. There are many islands and archipelagos with high economic potential as Tho Chu and Phu Quoc. In addition, coastal mangrove

system also has a high economic value. [2].

For the climate condition, here is the equatorial climate which is so favorable for crop development (rainy, hot weather), especially for fruit trees, rice and other food crops. Although the area of agriculture and fisheries is less than 30% of the country but MD contributes more than 50% national rice acreage, 71% of aquaculture area, 30% of the value of agricultural production and 54% of the national fishery production.

As above mentioned, rice in the MD is the most important staple food crop for both national food security and the country's economy. Therefore, MD is annually contributing more than 90% of Vietnamese exportation of around 4-6 million tons of milled rice. According to Bingxin [3], rice production is the major source of income for more than 75% of poor households and for around 50% of non-poor households in Vietnam.

In this region, there are 5 main fruit trees such as dragon fruit, mango, rambutan, durian and longan. Livestock and poultry farming are well thrived in many provinces/cities such as Tien Giang, Ben Tre, Tra Vinh, Vinh Long, Can Tho, Hau Giang. Aquaculture and fishing farming in the MD are thriving, meaning that seafood production accounted for 50% of the country. Province having the highest output of fisheries is Kien Giang and the largest aquaculture areas is An Giang.

Forest resources also hold important roles, especially the system of coastal mangrove forests, including mangrove system in Mui Ca Mau which is recognized as the World Biosphere Reserve, it is next to the wing Melaleuca forests in U Minh, Ca Mau, Dong Thap with a biological system is extremely diverse.

However, climate change is challenging agricultural production in Vietnam and MD, including increasing temperature, drought, salinization during the dry season and flood in the rainy season. The different agricultural systems are fluctuated by climate change and required different solutions and techniques adaptable to production systems accordingly.

Impacts of climate change have shown very clearly in the MD since late 2015 to early 2016 by salinization and drought. Many areas of rice and vegetables, fruit and seafood are lost, lives of many farmers are affected severely because its impact never occurred in the fertile plains and it was known as the "good weather" region ten years ago. Agriculture in the MD could be exhausted within the next three years at a rate of current saltwater intrusion. Agricultural land and food production will become scarcer and more expensive. [4].

## 2. Methods of Study

This paper taking climate change into consideration for suggesting suitable solutions proposes alternative agricultural systems for restructuring the current agricultural production systems, which are affected by saltwater intrusion, drought, and lack of freshwater, to create jobs and income for rural people. This study is based on a literature review, drawing

from a large set of data, documents and reports from various research institutions and from research and development projects by non-governmental and governmental organizations. Moreover, the proposal solutions are also based on directly interviewed farmers, relevant government officers, extension workers, and related companies in the areas of climate change impact (Kien Giang, An Giang, Bac Lieu, Tien Giang, Soc Trang, Ben Tre, Trà Vinh and Ca Mau) and by directly observed the impact of climate change in the provinces having 4 field trips by author from December, 2015 to July 2016. Finally, based on the MARD and local governmental strategies, farmer group discussion and interviews and the experiences of the author's own, some appropriate solutions and alternative agricultural systems has proposed to cope with adverse impacts of climate change in the MD.

## 3. Results and Discussion

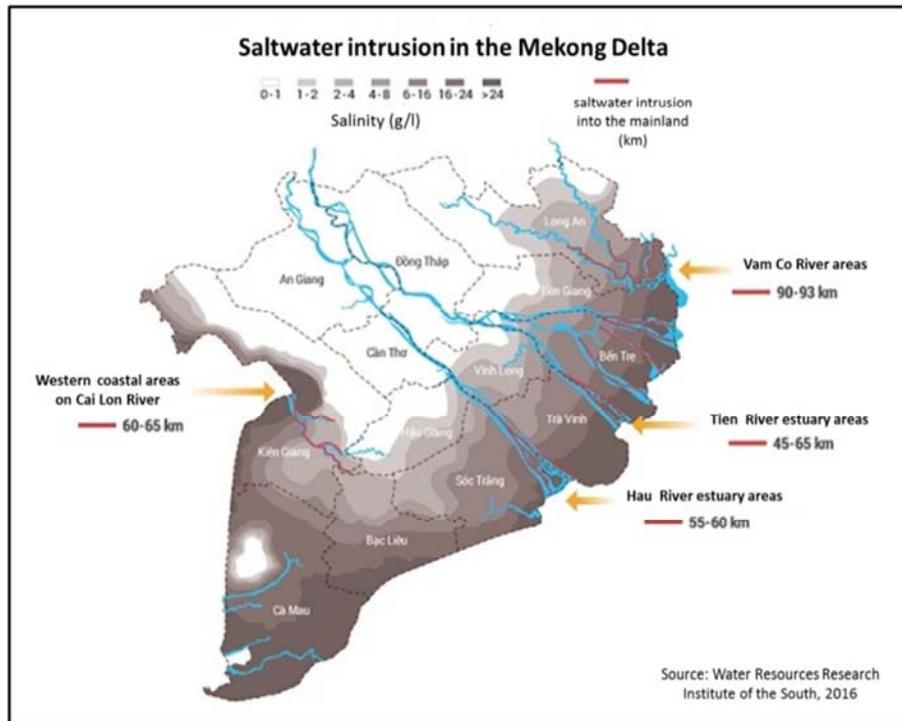
### 3.1. Salwater Intrusion - The Impact of Climate Change in the MD

MD is a downstream of the Mekong River contiguous to East Sea, in which the terrain is relatively flat and low and its two large low-lying zones are Dong Thap Muoi and Long Xuyen Quadrangle. Along with the mainstream – Tien and Hau Rivers, MD has the interlaced canals system with an average density of 4 km long in 1 km<sup>2</sup>, creating favorable conditions for tidal sea saltwater intrusion into fresh water rivers and internal fields, particularly in the dry season, when the water flow from upstream Mekong is lower.



**Figure 1.** The irrigation canals in Hung Yen village, An Bien District, Kien Giang province affected by salinization. Source: Trong Đạt/TTXVN.

Salty developments in the region are complex. Largest salinity often occurs mainly in April or May due to the influence of the tide in the East Sea, West Sea, or both. Also, due to the low flow from the upstream Mekong is also a major factor affecting the situation of salt water intrusion in coastal estuaries of the MD, in which the tide is the motivation factor, moving deep seawater into internal fields and inland, while quantity of water from upstream poured is limited.



Source: Water Resources Research Institute of the South Vietnam, 2016.

**Figure 2.** Saltwater intrusion in the Mekong Delta.

In addition, reduced rainfall, high evaporation of water are also factors affecting the process of salinization. Besides natural factors and human factors are also contributing to increasing saltwater intrusion when trying to exploit and use groundwater to meet the needs of development, production and local livelihood. Changing land use also has a certain influence on the situation of salt water intrusion [5].

Salinization is causing extremely severe consequences, affecting agricultural and aquacultural production as well as daily livelihood of the farmers in the MD. In particular, by the end of 2015 to early 2016, salinization developments in the MD are rated as the worst in 100 years ago. As early as February 2016, the salinity was seriously maintained at a high level. Along Tien and Hau rivers, salinity was at over 45 ‰, saltwater penetration into crop fields 70 km far from the river mouth, even up to 85 km in some places. According to the Center for Prevention and Mitigation of Natural Disasters, field is considered as infection of salinity when having 4‰ of salinization.

According to the report from Water Resource Directorate belong to MARD [12], since the end of 2015 to early 2016, about 90,000 hectares of rice was affected by salinization, in which 50,000 ha was heavy lost (Kien Giang 34,000 ha, Soc Trang 6.300 ha, Bac Lieu 5.800...). In the Winter-Spring season of 2015 - 2016, 104,000 hectares of rice affected on productivity (occupied 11% of cultivated area of 8 provinces along the East Sea severely affected by saltwater intrusion). However, the estimation for damage areas may come to about 340,000 hectares of rice is affected (occupied 35.5% of the cultivated areas of 8 coastal provinces). MD region is

currently the most severely affected by drought, saltwater intrusion, and continues to be affected in the future. In the year 2016, the highest saltwater intrusion was between March, 2016.



**Figure 3.** Many fields in the Ca Mau province withered as drought and salinity. Source: Ngoc Chanh, www.sggp.org.vn, 2016).

According to NASATI [5], since the end of 2015, all 13 provinces in the MD were affected by salinity, and 11 of 13 cities/provinces announced situation of drought, and saltwater intrusion. On 07/3/2016 Ministry of Foreign Affairs had the dispatch number 128/NG-DBA sent to the Embassy of the People's Republic of China in Vietnam requested the Chinese side to support for increasing flow of water discharge from Jinghong hydropower (Yunnan) of China to Lower Mekong Basin contributing to prevent drought, and saltwater intrusion, reduce damage for the Vietnamese people in the MD. The Chinese authorities have implemented an emergency plan to discharge water during the period from 15/3/2016 to 10/4/2016. In early April 2016, this water

source came to Vietnam and partly pushed the saltwater into the sea. However, this is not a permanent solution and proactive solution, which is only the solution for immediate situation.

**3.2. The Constraints and Challenges Caused by Climate Change in the Agricultural Production in the Coastal Provinces of MD, Vietnam**

The coastal provinces in the MD such as Kien Giang, Bac Lieu, Soc Trang, Tra Vinh, Ben Tre and Ca Mau have ecological diversity with enough 3 ecozones that are fresh, brackish and saltwater zones and having diversified farming systems.

Rice is the main crop in MD and is cultivated as monoculture pattern (single rice, double rice, triple rice pattern) or rice rotation (rice-upland crop rotation, rice-aquaculture rotation). Double rice and triple rice patterns are mainly applied in fresh water zone. In double rice system, farmers grow one short duration rice variety and one long duration rice variety. In triple rice pattern, farmers use short

duration varieties. One rice crop is applying in salinity zone or flooding zone, where they can grow one rice crop per year. In order to diminish the effect of climate change, Vietnam government stimulate the shifting from double rice/triple rice to rice-upland crops rotation. However, the most difficult is the market for the products of upland crops.



**Figure 4.** A rice field in Kien Giang province totally losts by salinity (Source: Nguyen Cong Thanh, 2016).

**Table 1.** The impact of climate change in 3 ecological zones of MD, Vietnam 2015-2016.

FRESHWATER ZONE	
<b>Major agricultural systems</b>	<b>Constraints and challenges</b>
<ul style="list-style-type: none"> <li>• 3 rice crops (Short duration varieties in Spring Winter – Autumn + Autumn summer – Summer Winter season)</li> <li>• 2 rice crops (Spring Winter season) + Short duration rice (Autumn Summer season),</li> <li>• Vegetables and upland crops: Melon, spinach, tomato, gourd, cucumber ... ,</li> <li>• Aquaculture production,</li> <li>• Small production of Livestock: Cattle, goats...</li> <li>• Fruit trees</li> </ul>	<ul style="list-style-type: none"> <li>• Saltwater intrusion even in the fresh water zone (improper sluice-gate),</li> <li>• Rice varieties with low tolerance to salinity causing damage and loss,</li> <li>• Poor quality of pesticides and fishing feeds.</li> <li>• Vegetables and upland crops: Market problems, lack of fresh water, saltwater intrusion.</li> </ul>
<b>BRACKISH WATER ZONE</b>	
<b>Major agricultural systems</b>	<b>Constraints and challenges</b>
<ul style="list-style-type: none"> <li>• Rice (Traditional rice varieties: Tai Nguyen, Hong Dan, Mot Bui Do, F1 rice varieties) Crayfish intercropping + Prawn rotation</li> <li>• Pork, poultry: Increase income and livelihood.</li> <li>• Eel (cá chình), goby, snakehead fish in nets, catfish (less)</li> <li>• White leg shrimp, Prawn (semi and intensive farming)</li> <li>• Wildlife: Crocodile, weasels, wild boars, snakes of all kinds...</li> </ul>	<ul style="list-style-type: none"> <li>• Saltwater intrusion induced rice death in large scale.</li> <li>• Pumping water discharged into the canals do not flow into the sea induced pollution.</li> <li>• Many companies discharged pollutants increasingly.</li> <li>• Rice - shrimp production failure despite good seed, good soil.</li> <li>• Crocodile unstable price; unexplained death of mass crocodiles.</li> </ul>
<b>SALTWATER ZONE</b>	
<b>Major agricultural systems</b>	<b>Constraints and challenges</b>
<ul style="list-style-type: none"> <li>• Intensive shrimp (60%), in which White leg shrimp with 40%.</li> <li>• Improving and semi-intensive shrimp (40%),</li> <li>• Vegetables, upland crops,</li> <li>• Livestocks and poultry,</li> <li>• Crabs, tilapia, seabass, goby, eel..</li> <li>• Oyster/fish cages and mollusc bivalves</li> <li>• Mangrove-aquaculture</li> </ul>	<ul style="list-style-type: none"> <li>• Intensive shrimp: Pollution of water sources (80-90 % losses, only 10-20% profits).</li> <li>• For improving shrimp only 15% have benefits.</li> <li>• Deeper aquifers and lack of fresh water.</li> <li>• Stagnant water does not drain to the sea as before.</li> <li>• Low quality of aquacultural varieties.</li> <li>• Lack of capital.</li> </ul>

Source: Group farmers interview by the author in early 2016 in some coastal provinces of MD.

In brackish zone, rice-shrimp model is being widely applied with the medium duration rice varieties and usually tolerant to certain salinity and good quality. The long duration varieties are traditional varieties with higher quality and greater salinity tolerance but lower yield than just grown in small areas of the Delta. However, several provinces have been developing the model of organic rice in the rice-shrimp farming system with higher profit for the farmers. This system is more profitable with lower risk and lower investment. Moreover, rice quality is also higher than that

under conventional rice since less fertilizer and less chemical pesticide use.

In salinity ecozone in the junctional sea provinces such as Kien Giang, Bac Lieu, Soc Trang, Tra Vinh, Ben Tre and Ca Mau, the cropping systems, are mainly grown with vegetables, upland crops in areas where fresh water (underground water) is available for irrigation, and aquaculture is shrimp, crab, fish of all kinds.

The impact of climate change in a number of agricultural production systems, in 3 ecological zones of MD can be

described as follows:

Drought and salinity intrusion fiercely in the early 2016 and will continue to affect the production and livelihood of farmers in the MD. According to the MARD, drought, salinity intrusion in the MD in 2015-2016 is particularly a serious disaster, which occurred once within the last 90 years, causing tens of thousands of households falling into misery. Lack of fresh water for production and for daily life; drought, saline intrusion caused severe damages for fruit, rice and vegetables production; many provinces and cities in the region have announced disaster situations of drought and salinity. How to cope with natural disasters, and to adapt to drought and salinity as well as to live with floods, is the question posed to the ministries and agencies concerned and the farmers of the MD before unusual impacts caused by change climate. [7].



Source: Nguyen Cong Thanh, 2016).

**Figure 5.** Farmer group discussion to find livelihood solutions adapting to climate change in the Mekong Delta.

### 3.3. Proposal Solutions for Alternative Agricultural Systems to Cope with Adverse Impacts of Climate Change in the MD

#### 3.3.1. Solutions and Planning



Source: Nguyen Cong Thanh, 2016).

**Figure 6.** Converted to aquaculture in the saline area is one of the livelihood solutions adapted to climate change in the MD.

Climate change now is the big problem of the world. India is also facing the same situation, as the author Anish Chatterjee [8] stated that signals of climatic change are already visible. Global climate change is going to affect major crops like rice, wheat, maize in India. Climate is the least manageable of all resources. Hence, to avert the ill effects of climate change, more attention has to be paid to other resources and technologies viz. soil, irrigation water, nutrients, crops and their management practices, to sustain the productivity and to ensure food and environmental security to the country. Adaptive measures are to be taken in a timely fashion, both at the farmers' level (backed by strong agriculture/climate research and application oriented outputs) as well as at the policy makers' level to enable the small and marginal farmers to cope with the adversities of climate change.

In India, the report from CDKN Asia (Climate & Knowledge Development Network) wrote that what are the adaptation and mitigation strategies? We need crops and varieties that fit into new cropping systems and seasons. We need to develop varieties with changed duration and varieties tolerant to high temperature, drought, inland salinity and submergence. We also need crops and varieties that tolerate coastal salinity and seawater inundation and varieties which respond to environment with high CO<sub>2</sub>. Lastly, we need varieties with high efficient utilization of fertiliser and radiation [9].



**Figure 7.** A sugarcane field in Soc Trang province affected by salinity (Source: Nguyen Cong Thanh, 2016).

As predicted by some scientists and the Intergovernmental Panel on Climate Change (IPCC), by 2050 the sea level will rise 2 meters above the present in MD, the coastal lowlands as Shoals coral, coral islands will be inundated at risk and the possibility of saltwater intrusion of seawater into the continent is a trend in the coastal areas.

To limit and cope with drought, salinity intrusion in the future, each locality should implement measures consistent with its conditions. However, at the macro/national level, it is necessary to conduct some common solutions such as:

(1) To strengthen monitoring and supervision, improve sanility forecasting;

(2) To strengthen international cooperation with other countries in the Mekong River Commission and China to share common interests in the development and prosperity of the whole region under the 1995 Mekong Agreement, signed bilaterally with each country or multilateral;

(3) Adjust the overall planning and agricultural production for regional planning, planning of agricultural production must be in the master plan includes the development of industry, tourism and agriculture;

(4) Selection of plants and animals adapted to drought conditions and saltwater, brackish water. The researchers conducted the long-term sustainability measures for local economic development, should step selection and breeding of plant varieties and animal can survive and thrive in drought environments, saltwater and brackish water;

(5) To strengthen the levee system and established several quadrilateral areas is one of the main priorities. Establishing protected areas before flooding, salinization, to be active in the taking of floodwaters for improvement of fields and serve aquaculture is crucial to ensure the production and life of the people, creating safe areas for flooding and saltwater intrusion;

(6) Constructing underwater dam, this is the solution reference for Vietnam, this solution has been adopted from the United States. Because saltwater has a larger proportion as compare to freshwater, so the saltwater should be layed below freshwater and form salty wedge;

(7) Develop and improve the work system for keeping freshwater in the delta;

(8) Building sea dikes, river dikes. This is a long-term project sustainability along the East Sea and the West Sea in response to sea level rise;

(9) Integrated management of water resources. This is one of the active measures and the most efficient management of freshwater resources, indirectly repel saltwater intrusion [5].

For the agricultural sector, climate change responses plan of MARD [6] in the cultivation field as follows:

- To study on the rational and efficient use of paddy land, rice production adaptable to climate change, with high quality and high value-added to serve consumers and export in the key rice growing areas;
- To study and application of synthetic models, model linking crop and livestock production, horticulture and fisheries, suburban agriculture, agroforestry, farming and ecotourism;
- To study on development and transfer of new plant varieties (all types) with high productivity and high quality adaptive farming conditions (tolerant to salinity, drought and acid sulphate soil), mode of cultivation (flooding, drought) for production of commodities in the model of climate smart agriculture;
- To study redeployment farming system towards diversification of crops and farming techniques, linking intensive cultivation to increase yield to resource environmental protection and risk control from the negative impact of climate change.



Source: Nguyen Cong Thanh, 2016.

**Figure 8.** Rice-shrimp intercropping and rice-shrimp rotation, is the model to adapt to seasonal salinity in the Mekong Delta. This can produce organic products to improve income, health and protect the environment.

In condition of India, the above solutions and planning can be similar in some contexts when Manas Ranjan Senapati [10] wrote that noteworthy interventions to reduce adverse impacts of climate change include:

- Improvement in forecasting & early warning systems;
- Establishing hazard & vulnerability mapping;
- Augmenting public awareness;
- Creating community-based forest management and afforestation projects; and
- Improvement in irrigation.

### 3.3.2. Opportunities and Challenges for Vietnam's Rice Sector

According to MARD (Vietnam Rice Restructuring Strategy Towards 2020 and Vision to 2030) [11]:

- The world import demands keep increasing in next 10 years (1.5% per year).
- Vietnamese rice market is able to expand when Vietnam joins new FTAs such as TPP, VN-EU.
- The investment of government, enterprises is strengthened; infrastructure is improved gradually.
- The development of science and technology about varieties, farming practices, storage and processing facilitation are also great opportunities to promote the rice sector.
- Besides these opportunities, Vietnam's rice production would encounter many challenges in the coming period.
- The difficulties and limitations of rice sector in Vietnam are not easy to overcome in short term.
- In addition, paddy land has been competed with other crop production and economic activities, and urbanization as well.
- Soil nutrient is depleted due to intensive farming.
- Water for rice production will be strongly disputed when the upstream countries build irrigation and hydroelectric projects that damage to natural

ecosystems in the basin and change hydrological regimes.

- Moreover, the rice sector also faces other challenges such as the changing consuming demand and higher competition from other exporting countries, changing policies from other importers toward self-sufficiency and import restriction and price fluctuation and,
- Adverse climate change.

### 3.3.3. Specific Targets by 2020

a) Ensuring rice farmers' profit in commercial rice production areas to be at 30% or more.

b) Over 75% of rice growing areas will be used certified seeds; amount of seed sown will be decreased to an average of 80kg per hectare in Southern provinces;

c) Over 75% of producing areas will be applied IPM; 50% or more of producing areas will be applied sustainable farming practices (3R3G, 1M5R, AWD, SRI, VietGAP other GAP, organic standards); fertilizer and pesticides will be used 30% or more lower than its current amount per production unit.

d) Post-harvest losses will be reduced to less than 8%

e) Emissions causing the greenhouse effect will be lowered by 10% in comparison with the current level.

f) In specializing areas of growing commercial rice, large-scale fields and material zones will account for 20% or higher.



**Figure 9.** Models of oyster, fishes cages adapted to saltwater intrusion in the Mekong Delta, and created livelihoods for farmers (Source: KHPT Newspaper, 2011 and Nguyen Cong Thanh, 2016).

### 3.4. Alternative Agricultural Systems to Cope with Adverse Impacts of Climate Change in the MD

- Improving the efficiency of 2 rice crops pattern of production.
- Transferring structure of 2-3 rice seasons affected by salinity into rice-shrimp rotation system.
- Improving the system of rice-shrimp farming in value chain linkage from production to consumption and producing organic products.
- Restructuring 2 rice crops and one upland crops (sesame, corn, soybean and greenbeans- combine with livestocks).
- Constructing intensive vegetable production areas – mushroom production
- Developing the model of oyster/fish cage and mollusc bivalves farming
- Expanding goby - shrimp farming (raising white leg shrimp after goby and keep remaining water)
- Converting to the system of grasses/weeds with tolerant to salinity combine with livestocks in the less effective intensive shrimp farming
- Improving and developing salt-artimia production system
- Improving aquaculture-mangrove forest system in combination with with ecotourism.

Research for adaptation to climate change in the MD in the country and cooperation with international assistance has been continuous. Research on technical solutions to shift from traditional farming to alternative farming systems adaptable to climate change helping the majority of vulnerable people can facilitate livelihoods consistent with climate change.

According to ADB [13], the Government of Viet Nam has requested the Asian Development Bank (ADB) for technical assistance (TA) to undertake a study on climate change impact and adaptation in the MD. The TA supports the Government's National Target Plan (NTP) for responding to climate change, as well as Viet Nam's commitments under the United Nations framework Convention on Climate Change. It complements the Government's national socioeconomic development plan and Comprehensive Poverty Reduction and Growth Strategy.

Total cost of the TA is expected to be \$1,630,000 equivalent, of which (i) \$800,000 will be financed on a grant basis by the Government of Australia, and administered by ADB; and (ii) \$500,000 will be financed on a grant basis by the Climate Change Fund. The Government will finance the remaining \$330,000 in kind, covering the costs of office accommodation, transport, utilities, remuneration for counterpart staff, as well as training and workshop facilities.

A study from ADB assistance in Ca Mau province [14] state that, refers to the vulnerability of poor and near poor households and people in the study area to the effects of climate change, and recognises that the incidence of poverty varies across the region, due to a range of 'special

difficulties' such as ethnicity, lack of access to agricultural land, education and health services, fresh drinking water, power and markets. Poverty diminishes the resilience and adaptive capacity of people and households, especially where people lack savings and capital for investment to adopt better production technology and also lack awareness and knowledge of adaption options available.

Other study results from ADB [15] assistance on technical solutions have been consolidated to the proposed alternative agricultural systems adapt to climate change in the MD over above when they state that prevention measures in the agricultural sector is currently ranked at full completion, just with the long-term improvement measures in areas such as upgrading dykes and sluice gates, improved crops and farming, processing of agricultural products as well as improved rice varieties and farming methods.

## 4. Conclusion

Climate change is challenging agricultural production in Vietnam and MD, including increasing temperature, drought, salinization during the dry season and flood in rainy season.

The result of this study displayed the impact of climate change, the constraints and challenges in the agricultural production systems in the coastal provinces of MD in the fresh water, brackishwater and saltwater zones which caused by saltwater intrusion and need for strategic solutions and actions to adapt to climate change. The different agricultural systems are affected differently by climate change and require different solutions and techniques applied separately to convert production systems accordingly.

The paper has proposed ten alternative agricultural systems to help ensure the livelihood of the rural population in salinization affected areas. Those are: Improving the efficiency of 2 rice crops production; Transferring structure of 2-3 rice seasons affected by salinity into rice-shrimp system; Improving the system of rice-shrimp farming in value chain linkage from production to consumption and producing organic products; Restructuring 2 rice crops and one upland crops; Constructing intensive vegetable production areas—mushroom production; Developing the model of oyster/fish cage and mollusc bivalves farming; Expanding goby - shrimp farming; Converting to the system of grasses/weeds with tolerant to salinity combine with livestock in the less effective intensive shrimp farming; Improving and developing salt-artimia production system and Improving aquaculture-mangrove forest system combine with ecotourism.

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