ASSESSING THE ECONOMIC EFFICIENCY OF CLIMATE CHANGE ADAPTATION MODELS IN THE MEKONG DELTA

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Abstract: *The Mekong Delta is considered the largest granary of Viet Nam since most of its cultivated area is continuously supplied by annual alluvium which is significantly fertile and suitable for rice development. However, the region has been highly suffering from climate change such as sea level rise, inundation, salinity intrusion, and erosion which are seriously threatening to agriculture development, food security, and causing damage to social-economic region. As an adaptation to impacts of climate change, many new economic models have been applied in some regions of Mekong delta, and gradually brought certain efficiency in terms of economy such as mangrove cultivating seedling garden (vuon uom), large rice-field, and rice-fish system. In order to apply and replicate these models for other regions in the Mekong delta, it is necessary to have comprehensive assessments on such aspects as ability on climate change adaptation, climate change mitigation, ensuring efficiency and sustainability in line with environment, economy and society. This paper presents approach for formulating and defining a set of criteria used for assessing climate change adaptation models in the Mekong Delta. The results show that all economic models highly adapt to climate change and bring high economic benefits. However, the applicability of some economic models is still limited.*

Keywords: *Climate change adaptation economic model, set of criteria, climate change, Mekong delta.*

1. Introduction

The Mekong delta is the largest granary of the Viet Nam. It plays the most important role in food security policy with contributing more than 50% of rice production in the whole country [1]. Currently, the Mekong delta is facing two major challenges as climate change. It is considered as one of the world's three most deltas to the sea level rise. According to climate change scenarios, in late 21st century, if the sea level rise rises 1m, about 40% of the Mekong delta area will be inundated. In addition, due to the climate change, the intensity and frequency of natural disaster such as droughts, soil and water salinity and other calamities have increased. As a result, it threatens food security and agricultural development, causes great human and property loose, damages social economic and cultural infrastructure, and imposes negative impacts on environment of Mekong Delta [2,3,4]. In response to climate change, over the past years, hundreds of initiatives, solutions, practices and models of climate change adaptation have been implemented, and tested on different scales in many fields across the country [5,6,7,8,9,10,11]. Among them, emerged economic models as potential climate adaptive practices at commune and district levels are on agriculture and forestry such as mangrove cultivating seedling garden (Vuon uom) [6], large rice-field [12], and rice-fish system [6]. They initially bring efficiency in terms of economy and be engaged to expand in the whole region. However, there are only a few sets of evaluation criteria to evaluate the effectiveness of adaptation models. Besides, they still exist many limitations such as

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the criteria set of CARE international in Viet Nam which has not given detailed criteria yet and has not evaluated point of criteria based on the priority of each locality [13]. Another set of criteria in Huynh Thi Lan Huong et al. (2015) also did not give appropriate scores criteria because of not considering the priority level in the context of each locality [14]. In addition, only a few studies have attempted to evaluate overall efficiency of such models with all aspects as ability on climate change adaptation, climate change mitigation/greenhouse gas mitigation, ensuring efficiency and sustainability in line with environment, economy and society. Therefore, the objectives of this work are: (1) Constructing and developing a set of evaluation criteria which covers all aforementioned aspects; (2) Evaluating three pilot economic models to identify their actual efficiency on climate change adaptation based on these criteria.

2. Methodology

The method of assessing the efficiency of climate change adaptation activities is different between scales as on global, national, provincial and local levels [15,16]. Therefore, the set of criteria/indicators evaluating the efficiency of the selected economic models is able to monitor the integration of climate change adaptation activities in sectoral and local plans as well as check their efficiency. These indicators not only measure adaptation processes but also quantify the results.

In Viet Nam, there have been a number of studies developing a set of criteria/indicators to evaluate the efficiency of climate change adaptation models. For instance, the Institute for Water and Environment, under the Viet Nam Academy for Water Resources belong to the Ministry of Agriculture and Rural Development (MARD) developed a set of indicators that evaluates the efficiency of climate change adaptation and mitigation models. CARE (2015) developed another set within its project in the Mekong Delta to identify climate change adaptation livelihood models [13]. Moreover, the SNV Netherlands in collaboration with the MARD proposed the indicators that need to be considered when developing a community-based livelihood model to respond to climate change. VNGO&CC and CCWG (2014) has conducted the research on criteria assessment for a model on response to climate change deployed in Viet Nam. Thereby, a model on response to climate change is assessed based on three criteria as adaptation, mitigation and sustainability index [17]. In the recent study of Le Van Thang et al. (2015), the method of investigation, interview, statistics, expert, SWOT and PRA method was used to develop a set of criteria to evaluate climate change adaptive capacity for models in the central provinces/ cities [18]. Additionally, the Center for Sustainable Rural Development suggested a set of indicators for piloting measures to support farmers to develop sustainable livelihoods in the context of climate change. The Viet Nam Institute of Meteorology, Hydrology and Climate Change has also developed a set of climate change adaptation indicators that is appropriate and applicable for Viet Nam to serve the state management of climate change based on the world's index framework [14].

In this study, the major methodology is based upon the results from local consultation, through four main stages: (i) Identifying the content to be consulted; (ii) Identifying the opinions and consensus of the expert group on the content to be consulted; (iii) Identifying reasons in case of disagreement; and (iv) Final evaluation.

In order to have this indicator set of evaluating the economic efficiency of the adaptive models, it is necessary to clearly define each specific group of indicators and criteria. Based on an assessment of the advantages and disadvantages of the methods that monitoring and evaluating adaptation in the world and in Viet Nam along with the consultation results of local departments and the questionnaires from local people who are deploying and implementing the climate change adaptation model, this study has proposed a set of criteria according to the importance of each criterion. The purpose is to evaluate and select effective livelihood models which adapt to climate

change to be proposed for replication. A general set of criteria is proposed with 6 main groups of criteria and 33 indicators corresponding to a maximum total score of 100 points; in which criterion on economic efficiency and the target of climate change adaptation showing the most important goal. The corresponding scores for each criterion are shown in the Table 1 below:

Table 1. Set of criteria for assessing economic efficiency of climate change adaptation models in Mekong Delta

Criteria	Content	Point
Socio-economic efficiency		**70**
Economic	1.1. Assessment of market needs	5
	1.2. Assessment of the investment scale	5
	1.3. Assessment of technical capacity	5
	1.4. Productivity	5
	1.5. Product quality	5
Institution	2.1. Regulation	5
	2.2. Financial policy	5
	2.3. Supporting program	5
Culture - Society	3.1. Diversify income sources and create jobs	5
	3.2. Increase number of beneficiaries	5
	3.3. Inherit and promote indigenous knowledge	5
	3.4. Mobilize the participation of women and ensure gender equality	2.5
	3.5. Mobilize the participation of ethnic minority groups	2.5
	3.6. Promote the participation of people with disabilities	2.5
	3.7. Promote the participation of vulnerable groups (single, etc.)	2.5
	3.8. The appropriateness of the model deployment location	5
Ability to cope with climate change		30
Climate change adaptation	4.1. Ability to adapt with current climate change	2
	4.2. Ability to adapt with climate change in the future	2
	4.3. Adjust the crop/seedling structure or source of materials to adapt with climate change	2
	4.4. Take advantage of beneficial opportunities from climate change	2
	4.5. Impacts of greenhouse gases	2
Environment	5.1. Impacts on ecosystems/biodiversity	2
	5.2. Sustainable use of natural resources	2
	5.3. Energy conservation and energy efficiently	1
	5.4. Using renewable energy	1
	5.5. Reduce discharge into water and soil environment	2
	5.6. Increase waste reuse and recycling	2
	5.7. Adaption capacity from the changes of ecosystems	2

Criteria	Content	Point
Ability to cope with climate change		30
Management	6.1. Resources	2
	6.2. Financial resources in the community	2
	6.3. Scientific and technical application	2
	6.4. Risk management plan	2
	6.5. Replication ability	2
Total		**100**

The efficiency of economic models based upon a set of criteria is evaluated according to the rank of scores as <50: poor efficiency, 50-60: low efficiency, 61-80: moderate efficiency, 81-90: high efficiency, and 91-100: very high efficiency.

3. Results

Over the past years, the emerged economic models such as mangrove cultivating seedling garden (Vuon uom) [6], large rice-field [12], and rice-fish system [6] have been recognized to bring benefit for farmer and be engaged to replicate to other regional and Mekong delta. In this section, such economic models are consecutively introduced first, then they are deeply analyzed and assessed based on the new set of evaluation criteria to identify their actual efficiency on both climate change adaptation and society-economy.

3.1. Climate change adaptation models

3.1.1. Mangrove cultivating seedling garden in An Thuy, Ba Tri, Ben Tre

The mangrove cultivating seedling garden is in large scale with area larger than 2.2ha. It is designed and built for long-term use of more than 10 years. Such mangrove species are cultivated including Sonneratia caseolaris (bần chua), Avicennia alba (Mấm), Rhizophora apiculata (Đước), Lumnitzera racemosa Willd (Cóc),… The mangrove cultivating seedling garden helps local resident to be more proactive in cultivating quantity, category and planting seasons than traditional model, in which mangrove trees are collected from natural sources and temporarily cultivated in the garden [6].

Climate change mitigation and adaptation/ GHG mitigation: mangrove species which are nourished for a long time in the garden, strongly develop root and trunk. Therefore, they can cope with serious ecological conditions in the afforestation areas along the outside of the dyke, so they help coastal mangrove ecosystems increase resistance and rehabilitated ability in the context of climate change. In addition, the development of coastal mangrove ecosystems increases carbon absorb ability, contributing to mitigation of greenhouse gas/mitigation of climate change.

Environmental efficiency and sustainability: The economic model helps to increase the resistance and resilience of the coastal ecosystems. Therefore, it has high efficiency and environmental sustainability.

Economic efficiency and sustainability: an area for mangrove cultivation is about 60% of garden's size. There are about 100 pots with an average potting bag of 15 × 25cm, and estimated density of bare-root seedlings is around 250 tree/m^2. An estimated production is approximately 1,000,000 small trees per year after reducing losses of about 20%. If the expected payback is 10 years and the annual depreciation is 223,736,000 VND/year equivalent to 224 VND/tree of depreciation, the price of seedling for sale still ensures profitable business.

Social efficiency and sustainability: Every year, the mangrove cultivating seedling garden provides 25,800 work for local labor, equivalent to 98 workers. Therefore, it contributes to the job creation for local idle workers, increasing income and improving living standards.

Policy efficiency and sustainability: The mangrove cultivating seedling garden is considered a "green model", therefore, it is easy to achieve the approval and support from local government and international organizations.

Replicating ability: the model is suitable for mangrove coastal ecosystem in Mekong delta. Therefore, coastal provinces in the Mekong delta can apply. However, it is depended on character of each region to select species for growing.

3.1.2. Assessment of production model of large rice field in Nga Nam district, Soc Trang

The large rice field is a model of linking 4 intensive rice-growing partners including local government and departments; scientists (from research institutes/university and local research organizations); businesses (input agents, traders, food companies, food security companies, mill and scrub companies); farmer (individual farmer and production cooperation groups). Farmers who join the large rice field, get more benefit than traditional production due to receive cultivated technical assistance (varieties, fertilizers and pesticides) and consumption of the product [12].

Climate change mitigation and adaptation/ GHG mitigation: The large rice-field model significantly depends on natural conditions, so it is still strongly influenced by weather and climate. However, due to receive the technical assistance and advice from experts and scientists, it's ability to adapt to climate change is higher than the traditional production.

Environmental efficiency and sustainability: It can reduce the level of increasing disease, but it has not yet effectively improved the level of impact on environment from natural resources and causing quite high impacts on biodiversity.

Economic efficiency and sustainability: The model reduces investment cost and get high profits compared to traditional production.

Social efficiency and sustainability: Timely risk forecasting and prevention; effective irrigation system; reducing working time; receiving instructions on farming techniques; and getting consumption and supplied product.

Policy efficiency and sustainability: Getting support from local government and scientists.

Replicating ability: The model is quite suitable for cultivation in Mekong delta, so most regional in Mekong delta can apply.

3.1.3. Rice-fish system

The rice-fish system is a model which inter-crops rice and fish. The model is based on the principle of support and using nutrition between rice and fish, it therefore, is energy saving, environmental friendly, and goo adaptation to flood conditions [6].

Climate change mitigation and adaptation/ GHG mitigation: The model is basically implemented on freshwater ecosystems. It is sustainable agriculture production, providing diversification of rice production and adapting quite well to changes of weather and hydrological regime.

Environmental efficiency and sustainability: Rice field is a huge reservoir to reduce flood in large areas, provide habitat for aquatic species and contribute to biodiversity conservation. Besides, fish can eat some harmful insects and limit weeds in the rice field, so farmers use less pesticides in killing grass for rice trees.

Economic efficiency and sustainability: The model helps farmer increase profit compared to just rice-monoculture model. According to survey results during 2005 to 2010, 100% of farmers get interest on average. Extra profit from raising fish is from 8 to 18 million VND/ ha/year.

Social efficiency and sustainability: Utilizing idle times of farmer, settling jobs well, and optimizing agricultural land use.

Policy efficiency and sustainability: It is easy to receive approval and support from local government and international organizations

Replicating ability: The model is easy to apply and implement, especially in localities with large areas of rice cultivation and low-lying terrain. Some other provinces in Mekong delta can apply this model such as An Giang, Dong Thap, Vinh Long,…

3.2. Assessment of economic models adapting to climate change

Table 2 describes the assessment of

economic models adapting to climate change based on the set of evaluation criteria on climate change adaptation, climate change mitigation/greenhouse gas mitigation, efficiency and sustainability on environment, economy, society and policy, and replication ability of the model. The results show that all economic models have a relatively high total scores, ranging from 70 to 80. Among three models, the mangrove cultivating seedling garden gets the highest total score with 85 points. The score of climate change adaptation, climate change mitigation, and efficiency and sustainability on environment are quite high because the mangrove cultivating seedling garden is considered as a green model to enhance the resistance and resilience of coastal ecosystem. However, the score of economic efficiency of the model is lower than the large rice field and rice-fish system because main target of this model is to create materials for coastal forest plantation to mitigate the impacts of climate change. Whereas, the main goals of the large rice field and rice-fish system are to increase economic efficiency, so their score of economic efficiency are higher than the mangrove cultivating seedling garden. However, their score of climate change adaptation, climate change mitigation and efficiency and sustainability on environment are lower. In addition to environmental effectiveness and ability on climate change, the mangrove cultivating seedling garden has the highest potential for replication because it receives a high consensus of local organizations and people. Besides, mangrove tree cultivation is not difficult for local people and the survival rate of tree is quite high. However, the large rice field and rice-fish system much depend on many factors such as topography and consensus among the stakeholders. Therefore, the ability of replication is still low.

Table 2. Assessment of economic models adapting to climate change based on the set of evaluation criteria

No	Criteria	Score		
		cultivating seedling garden	***Large rice field***	***Rice fish system***
1	Climate change adaptation	30	20	30
2	Climate change mitigation/greenhouse gas emission reduction	10	10	5
3	Efficiency and sustainability:			
	- *Environment*	10	5	10
	- *Economy*	5	10	10
	- *Society*	10	10	10
	- *Policy*	10	10	10
4	Replication ability	10	5	5
	Total	**85**	**70**	**80**

4. Conclusions

Based on the mentioned data and approach on assessing economic models from set of evaluation criteria, the main results of this study are as follow:

1. The set of evaluation criteria and its major methodology for evaluating the economic models in terms of climate change adaptation is based upon the results from local consultation. The set of evaluation criteria covers and evaluates all aspects such as climate change adaptation, greenhouse gas emission reduction, efficiency and sustainability on environment, economy, society and policy, and ability of replication.

2. The economic models including the

mangrove cultivating seedling garden, large rice field and rice-fish system, although the score for each aspect is quite different because of highly dependent on the main purpose, all models have quite a high total points, ranging from 70 to 85. All models have a high ability on adapting to climate change, mitigating climate change, reducing greehouse gas emission, and having economic and social effectiveness. However, the ability on replication of large rice field and rice-fish system are still limited.

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