

DROUGHT VULNERABILITY MAPPING OF MEKONG DELTA USING PARTICIPATORY APPROACH

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Abstract

In general, Mekong Delta belong Viet Nam is not directly affected by storms and typhoons brewed from the East Sea. The highest intensity rainfall normally occurs during the wet period from May to November. Once such natural impacts occur, the ensuing torrential rain and floods can cause severe damages to the region. The dry season is generally prolonged more than wet season. Pressure of water using of region is usually higher than others. Drought is common natural disaster and usually happens in Mekong Delta. Drought combines with hot which have been big disaster potentiation in region when lacked of water from upstream rivers and reduced daily, small flood and the changeable weather in recent years. All of them has been caused the pressure increasing to the economic, environment and social aspects of Mekong Delta. Based on the assessment of draught impacts, we briefly made the vulnerability map for the Mekong Delta, which is initial condition to support the plans on the water resource use and management... in the region.

Keywords: Drought, climate change, vulnerability, Mekong Delta, Environments, society, economic

Introduction

The Mekong Delta lies within the humid tropics, characterized by consistently high mean monthly temperatures (25–29°C) and high seasonal rainfall (1200–2300 mm). Generally, the Mekong Delta get a huge water volume from Mekong River (flood) and annual rainfall. But, in some recent years, the Mekong Delta not have flood or only has small flood from upstream Mekong River Basin. It caused the shortage of water for the irrigation and domestic use. Beside on the situation of water shortage, the Mekong Delta also have faced with the salinity water intrusion deeply into interior field and main rivers. It caused plus

difficult for local production and living. Discharge of the Mekong River exhibits strong seasonal variation in correspondence rainfalls. The low flow period (December to May) occurs during the dry season and the earliest stages of the wet season (Thuan, 2006) as shown in Figure 1.

The topography of Mekong Delta is flat with a dense canal network, which is strongly influenced by the annual salinity water intrusion from East Sea. Sometimes, the intrusion distance is as far as 40-50 km from the sea in some main rivers as Hau and Tien Rivers, which has serious adverse effects on rice and fruit trees. (Sam,

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2004; Thang, 2005)

The Mekong Delta (MD) is the main agricultural production region in Viet Nam due to fertile soils and abundant water sources. MD has about 4 million ha of rice area, and more than 18 million tons of rice produced annually – half of the total amount of paddy rice in Viet Nam. It has also a large fruit production with cultivating area more than 252,000 ha and annual production about 3 million tons. The MD had high economic growth in the 1996-2004 periods with an annual growth rate of 11.2 % (compared with the national growth rate of 7.0 %). In the MD, rice is still the most important crop. In 2004, the total rice area of the MD was 3.8 million ha, accounting for 86% of total crop area. The average rice yield was 4.9 tons/ha and total paddy rice production was 18.5 million tons. In the period of 2000-2004, rice area decreased by 0.8 percent annually whereas the yield and output increased by 3.3 and 2.4 % per annum respectively (Hung, 2014).

The low rainfall and high evaporation during the annual dry season place constraints on human habitation and activities in the Mekong Delta. Such conditions also give rise to other

problems such as salinity intrusion in coastal areas and acidification in ASS (Acid Sulfate Soil) areas. Shorter periods of dryness, which occur during the onset, or toward the end, of the wet season in some years, may also be extremely damaging to newly planted crops (Nien, 2001).

The drought phenomena in Mekong Delta: Historically, serious drought ravaged the region from April to June of 1983, 1992, 1998, and from October to December of 1958 and 1992. Drought during these years affected 4,000 to nearly 230,000 ha of farmland, and entirely destroyed 1,000 to 390,000 ha. The winter- spring and summer- autumn drought in 1998 caused shortage of water for 1,100,000 people, affected nearly 274,850 ha of summer-autumn crop area and destroyed over 32,000 ha. Therefore, an effective and comprehensive hydro-meteorological disaster management plan is required in this region, as the one of the key economic zones of the nation, to preserve and sustain its resources and richness (Sam, 2004).

Based on the summaries of Department of Cultivation (MARD), there was about 300,000 ha rice areas in Mekong Delta impacted by the drought – salinity situation in the dry-season 2013.

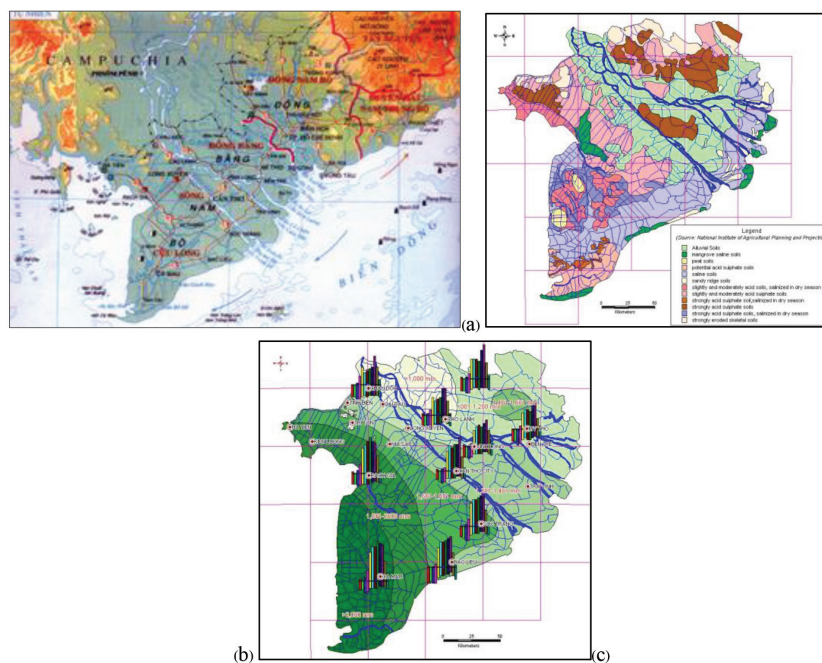


Figure 1. Topography (a), soil (b) and rainfall (c) distribution maps of Mekong Delta

There were more 100,000 ha rice areas impacted directly, affected seriously to capacity as shown in Figure 2.

Therefore, the impacts by drought to Mekong Delta are very clear and daily serious. Drought impacts caused a lot of losses for Mekong Delta's production and livings of local community. It caused losses to especially economic, environment and social sectors. Or, it caused vulnerability to Mekong Delta.

Assessment method of drought impacts and the vulnerability

Impact assessment examines the consequences of a given event or change. For example, drought is typically associated with a number of outcomes. Drought impact assessments begin by identifying direct consequences of the drought, such as reduced

crop yields, livestock losses, and reservoir depletion. These direct outcomes can then be traced to secondary consequences (often social effects), such as the forced sale of household assets or land, dislocation, or physical and emotional stress. This initial assessment identifies drought impacts but does not identify the underlying reasons for these impacts (Wilhite, 2000, White, 2002).

The impact assessments caused by drought are implemented by using questionnaire combined with directly interviewing each stakeholders or groups of stakeholders. The approach has strong points which able to get all difference cases and opinions of many stake holders. It has week point that the interviewers have to explain carefully to all stakeholder before interviewing (Kha, 2011; Pauw *et al.*, 2011). So that, to achieve the consistent results in the

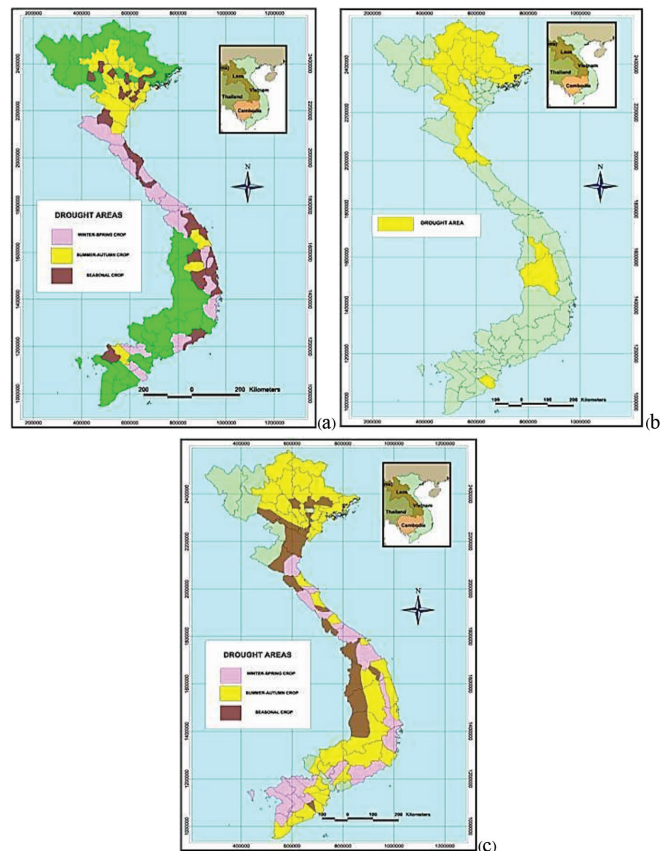


Figure 2. Drought maps in 1997 (a), 1998 (b) and 1999 (c) in Viet Nam
Source: Central Board of Statistic

assessment, the drought impacts should be classified as economic, environmental, or social, although many impacts may span more than one sector. Recent drought impacts, especially if they are associated with severe to extreme drought, should be weighted more heavily than the impacts of historical drought, in most cases.

For impact's types assessment caused of the drought in Mekong Delta, consultant has to follow the *methodology* shown below:

- Meeting with all relevant stakeholders (the representatives of line agencies of provinces related to environment management, irrigation, agriculture, aquaculture, ... production and social organizations) assess all drought impact types and impact's levels in Mekong Delta which is officially identified as one of the most drought prone areas of Vietnam. The evidences concerned with the drought impacts are classified three main sectors as shown in Tables 1 to 3.

- Collect and bind all provincial data from all national consultation meetings on types of drought basal impact's types and causes assessment. Because, there are many drought impact's evidences of many sectors in Mekong Delta. Some sectors have same drought impacts evidences as environmental and transportation sectors or as agriculture and aquaculture sectors. So that, we have applied the AHP (Analysis Hierarchy Process) to find the priority levels of the drought impacts in several sectors. The AHP will help us to find the main causes to make the drought and drought impacts happened in each sector and which kind of sectors have the serious impact level due to drought.

Drought impacts to economic, environmental and social sectors awarded by local community in Mekong Delta can be grouped into three different types (1) historical drought; (2) current drought; and (3) potential drought.

The analysis and foundation of major drought impact types were through three criteria such as:

- Cost: From list of drought impact types happened in the past, at present and potentially in future, which types to cause damage to economic, environment and social sectors are selected with highest agreement numbers of provincial

representers.

- Distribution: From list of drought impact types happened in the past, at present and potentially in future, which types equally distributed or considered at most of areas in Mekong Delta are selected with highest agreement numbers of provincial representers.

- Growing: From list of drought impact types happened in the past, at present and potentially in future, which types continuously growing in next periods are selected with highest agreement numbers of provincial representers.

- Publish priority: From list of drought impact types happened in the past, at present and potentially in future, which types are known and cared a lot by local community.

- Recovery: From list of drought impact types happened in the past, at present and potentially in future, which branches impacted by drought considered that could be recovered after drought gone and selected with highest agreement numbers of provincial representers.

Identification of the vulnerability grade due to the drought impacts for the provinces in Mekong Delta have many methods. After analysis, we applied the vulnerability identifying method in the climate change impact assessment. The vulnerability assessment is presented by Intergovernmental Panel on Climate Change in 2011. The vulnerability due to drought impacts is identified by equation:

$$V = f(E, S, AC) = 1/3 (S + E + 100 - AC) \quad (1)$$

There are:

V: Vulnerability of system/object don't adapt with drought situation. The vulnerability is a function of expositive index, sensibility and adaptability of system/object.

E: Expositive index: the index mentions be impacted due to drought. The expositive index is identified by equation (2):

$$E = \sum_{i=1}^n \frac{E_i}{K_{Ei}} \quad (2)$$

K_{Ei} is prior weight and E_i is normalized number of criterion E_i .

S: Sensibility of sector/system/object or natural factors with drought. This index usually

Table 1. The impacts of drought into economical sector

Items	Impacts
Agriculture	<ul style="list-style-type: none"> - The crops were damaged continuously - The capacity of crops was reduced - An income of farmer was reduced due to the low crop capacity. - An affectivity of cultivatable land was reduced. - An occurrence of types of insects caused the damages for crops. - An irrigation fee increased. - A cost of construction and improvement irrigation system increased.
Livestock	<ul style="list-style-type: none"> - A production reduced - A milk production reduced - A cost of building or repair the water supply system increased - A price of food for livestock increased, transportation fee increased. - A rate of animal death was raised while a weight was reduced. - An interruption in genesis cycle (generate low, death rate raised) - A fire/explode risks happened.
Power	<ul style="list-style-type: none"> - A need of energy increased while the provide capacity reduced. - A cost of energy sector and customers increased because it must change the hydropower by other more expensive sources.
Foresting production	<ul style="list-style-type: none"> - Losses of foresting land were due to the primary forest fired. - Occurred insect damaged plant - Insects destroyed forest plant. - Effective use of forest land was reduced - Directive losses were for plants, especially for young trees.
Aquaculture	<ul style="list-style-type: none"> - Environment of aquatic species were influenced. - Fish and other aquatic species were loosed because the flow reduced.
Tours and relax	<ul style="list-style-type: none"> - Losses for producers and business about the relax equipment - Losses related to relax programs were as the fishing, boating...
Water supply	<ul style="list-style-type: none"> - Benefits reduced - Fee of water transportation for customers increased - Cost for the new building or repairs water supply system increased.
Transportation	<ul style="list-style-type: none"> - Losses caused of reduce transport capacity on river and canal system.
Food production and provides	<ul style="list-style-type: none"> - Situation of lack of foods caused of the production reduced in agriculture and aquaculture sectors. - Price of food increased - Other fees were higher due to food's role.

Table 2. The impacts of drought into environmetal sector

Items	Impacts
Environmental	<ul style="list-style-type: none"> - Frequency and intensity of forest fires were increased. - The fire situation in cities and rural was more terrible when it lacked water to stamp out the fires. - Smoke and dust of a fire affected to the air. Dust and polluted components in the air were increased while the ability of stamps out fire was reduced. - Erosion of cultivate land due to wind. - Desertification. - Environmental ecosystem was downgraded and threatened seriously. - Living condition lacked food, drinking and disease due to drought made the vulnerability situation of animals increase. - Emigration and concentration of the wild animal causes the phenomenon that was in some areas to focus too much, while in some other ones was too little. - Loss was for crops because of the water-short and insects.

used in the assessment follow the economic – social sectors and natural aspect. The sensibility is calculated by the equation (3):

$$S = \sum_{i=1}^n S_i * K_{Si} \quad (3)$$

K_{Si} is a prior weight and S_i is normalized number of criterion S_i .

AC: Adaptability is situation, in which the system/object could mitigate the damage caused by drought, or make use of opportunities due to the bringing of advantageous impacts. The adaptive factors are the economic – social sectors, community conceive... the adaptive factor is calculated by the equation (4):

$$AC = \sum_{i=1}^n AC_i * K_{ACi} \quad (4)$$

K_{ACi} is prior weight and AC is normalized number of criterion AC_i .

Based on the mark range is proposed by Southern Australia Administration Association

(Schmoldt, D. L., 2001), the state of sensibility, expositive, adaptability and vulnerability will be as shown in Figure 3 and Table 4.

For implementation under above method, consultancy group (National consultant, Members of DMP, National Coordinator of DMP) have implemented some national workshops with the participants from line agencies, local management administration of provinces.

Identified the drought impacts and vulnerability map

Historical drought impacts are occurred in the past and likely or unlikely happening recent years. Current drought impacts are happened in last years (1 to 5 years) and they are like or unlike the types of impacts in the past. The recent drought impacts, especially if they are associated with severe to extreme drought, should be weighted more heavily than the impacts of historical drought, in most cases. And potential drought impact is the major impact which can causes significant damages to agricultural product or main households' income in future (Hung,

Table 3. The impacts of drought into social sector

Items	Impacts
Healthy	<ul style="list-style-type: none"> - Made a psychology tensely and unstable for people; - Wealthy was threatened because of causes related to water resources as: living water resources were polluted, sewage drainage pipe system was jammed, pollution stored and kept, quality of groundwater was reduced. - Reductions in nutrition because the food sources were limited due to expense; diet regime due to the tense. - People were threatened by diseases due to over high temperature or lacks nutrition. - Livestock was died of malnutrition, lack of food, diseased, ... - Public safety from forest and range fires; - Famine risk happened: lack of foods due to low productivity, ...
Social conflicts	<ul style="list-style-type: none"> - Conflicts between the water-users; - Conflicts about politics; - Conflicts in management procedures; - Other social conflicts (science, transmission media...)
Living quality/ behaviors changed	<ul style="list-style-type: none"> - Loss for the constructions which had cultural values; - The poor situation increased - Migration (from rural to urban areas, neighboring countries) - Creative activity was reduced or deformed
Respond with the drought	<ul style="list-style-type: none"> - Awareness of equity in distributing the reliefs must depend on eco-social condition, ethnicity, ages, gender and seniority. - Lack of data/information - Lack of coordination and propagation - Loss of believe on government

2013).

The identification drought impact types to each sector in Mekong Delta

The drought impacts to Mekong Delta's economic sector: Based on the discussions and chooses of provincial representatives related to irrigation and agriculture, aquaculture productions in drought impacts assessment meeting, we can see that most of drought impacts types appeared in the past, at present and potentially in future. From the set of chooses on the drought impacts to all sectors, we analyzed and ranged the type of drought impacts chosen a lot from high to low (the drought impacts' types chosen when there are high choose numbers (more than haft of number provinces in Mekong Delta) or the high priority levels (more than 50%). The main drought impacts' types in economic sector are summarized and presented in Figure 4.

The drought impacts to Mekong Delta's environment sector: Based on the discussions and chooses of provincial representatives related to environmental sector (as the environmental centers, provincial departments of natural resource environment) in drought impacts assessment meeting, we can also see that most of drought impacts types appeared in the past, at present and potentially in future. The main drought impacts' types in the environmental sector are summarized and presented in Figure 5.

The drought impacts to Mekong Delta's social sector: This is difficult identification of drought impacts' types. Because, there are over many apparent evidences concerned with damages, loss or vulnerates with many kinds of natural/artificial causes. Beside on the AHP method, we also applied the fill-form to get the real drought impacts from the collected information set. The main drought impacts' types in social

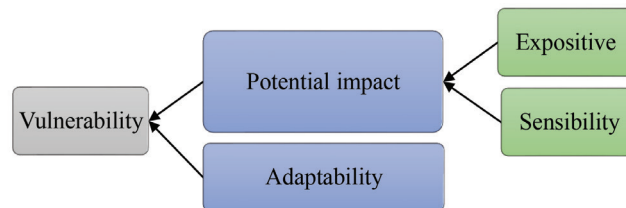


Figure 3. Assessment model of vulnerability
(Source: Intergovernmental Panel Climate Change)

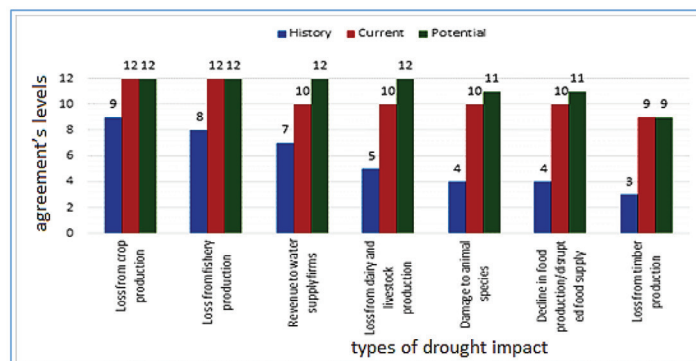


Figure 4. The agreement's levels about types of drought impact to economic sector

Table 4. The mark range of assessment

Identification	Very low	Low	Middle	High	Very high
Number Index	0 - 20	21 - 40	41 - 60	61 - 80	81 - 100

(Source: Schmoldt, D. L., 2001)

sector are summarized and presented in Figure 6.

The major drought impacts to each sector in Mekong Delta

Based on above results about the identification of drought impacts types to economic, environment and social sectors in Mekong Delta, we can analysis to find the major drought impact types to these sectors. Therefore, after assessment, we can consider some major drought impact types to economic, environment and social sectors in Mekong Delta, such as:

- Economic sector: (i) Annual and perennial crop losses; (ii) Costs to energy industry and consumers associated with substituting more expensive fuels (oil) for hydroelectric power; (iii) Damage to crop quality; (iv) Damage to fish habitat; (v) Income loss for farmers and others directly affected; (vi) Increased energy demand and reduced supply because of drought-related power curtailments; (vii) Insect infestation; (viii) Loss of farmers through bankruptcy; (ix) Loss of young fish due to decreased flows; (x) Loss to industries directly

dependent on agricultural production (e.g., machinery and fertilizer manufacturers, food processors, etc.); (xii) Plant disease; (xiii) Reduced productivity of cropland; (xiv) Unemployment from drought-related production declines; (xv) Wildlife damage to crops.

- Environment sector: (i) Water quality effects; (ii) Loss of biodiversity;

- Social sector: (i) Population migrations; (ii) Rural areas; (iii) Increased poverty in general.

The priority levels of all major drought impact types mentions the impacted levels or serious levels of them to people (economic and society) and nature (environment). They are not generally like other. Based on the rank about priority levels of provincial representatives, we can summary and show on Figure 7.

The causes of major drought impact types

Based on the major drought impact types to economic, environment and social sectors, we can identify what kinds of major causes to make these impact types in drought period. We

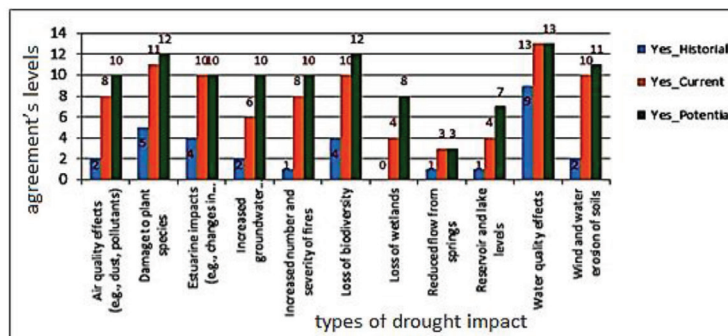


Figure 5. The agreement's levels about types of drought impact to environmental sector

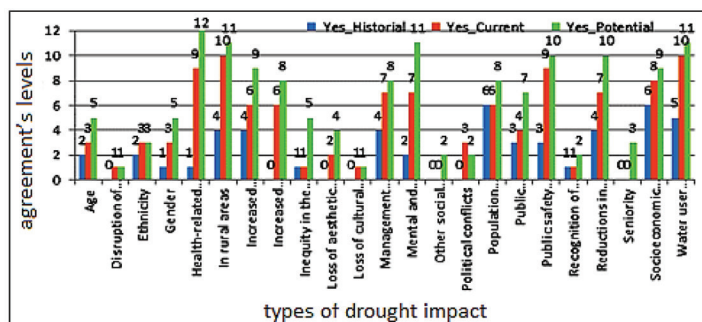


Figure 6. The agreement's levels about types of drought impact to social sector

have used the drought risks reduction matrix table in drought impact type's assessment meeting to find the major causes through the discussion of participants.

The major causes of drought impacts types of the economic, environmental and social sectors were related to the drought's origins as well as its results such as:

The natural changes (the water resources, the land resources, hydro-meteorology) as: The salinity intrusion from sea; the lacked fresh water for livings and production; the current weather varies as the rain was reduced and non-rule, flood was small and occurred late, the temperature increased high and the time lack of water was more lengthen...

The economic activities: The non-conformity with breed crops about type, planting methods; cropping schedule; fertilizer for crops; lacked of fund as well as lacked of technology for production...; The risks of production weren't interested (production insurance), it is especially in the agriculture, aquaculture which their products were depended on the natural conditions very much. Additionally, the causes were from the weakness of irrigation system which had the functions by the keeping fresh water and preventing salinity intrusion. The causes were also from the O&M.

The community's awareness: the using resources was untrue, wasted and non-science;

the awareness about the drought and climate change as well as the adaptation/responding activities were limited and low.

Vulnerability due to drought impacts of Mekong Delta provinces

Above item, it considered the main causes of vulnerability for economic, environment and social sectors in Mekong Delta, which are impacted by drought. The main contents of the item will consider the activities in mitigation and response methods to drought impacts to cause of vulnerability in Mekong Delta. Based on the list of major fields impacted by drought in Mekong Delta provinces, we can identify the vulnerability of drought with 100 range. The mark range is (i) Very serious vulnerability (81 – 100); (ii) Serious vulnerability (61 – 80); (iii) Middle serious vulnerability (41 – 60); (iv) Low serious vulnerability (21 – 40); (v) Very low serious vulnerability (0 – 20).

The Figure 8 and 9 of vulnerability of Mekong Delta provinces show below. The vulnerability of Mekong Delta provinces is from middle to low.

Conclusions and Recommendation

The dry season was prolonged to become cause of drought. So that, the local economic, environment and social sectors are impacted by

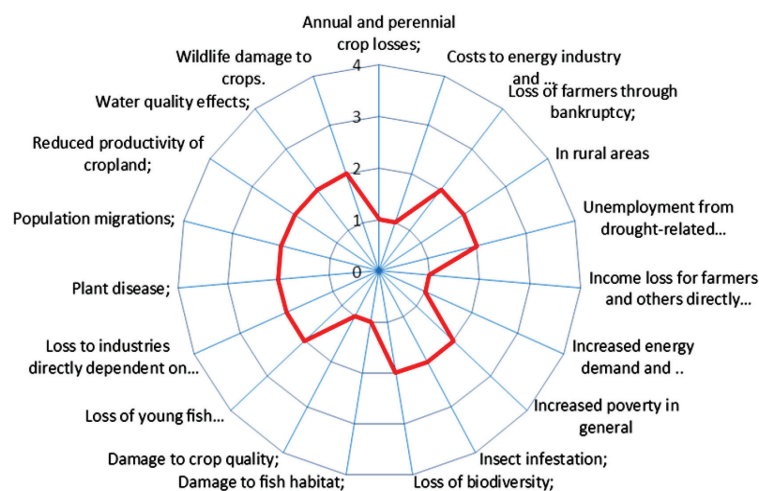


Figure 7. The priority rank of major drought impact types to sectors in Mekong Delta

drought and salinity water intruded into Mekong Delta. Through discussion of local participators in vulnerability assessment meeting, the major sectors impacted by drought are agriculture, aquaculture, water supply, water quality and life quality in Mekong delta.

The major causes to make the drought impacts types are identified such as salinity intrusion, lack of fresh water for living and production, O&M hydraulic works system weakness, ... Through discussion, all participators agreed that has to apply and implement the mitigation and response activities to reduce drought impacts. Based on the mitigation constructions have done in Mekong Delta, the respond level of all provinces has found.

Through the sensibility, expositive and adaptability of Mekong Delta's provinces, the vulnerability grade of each province is calculated. It is a source to map the vulnerability map due to the drought impacts.

Drought is extreme weather with lack of water from rain and upstream flow in Mekong Delta. It is still a little and non-carefully. Most drought researches based on the equal water resources as upstream flow, groundwater or water stored in canal system with demands from production and living. However, causes of drought impacts types include salinity intrusion; ineffective of O&M hydraulic works system as well as production as cropping schedule, breeds of crop and community's awareness. So that, it

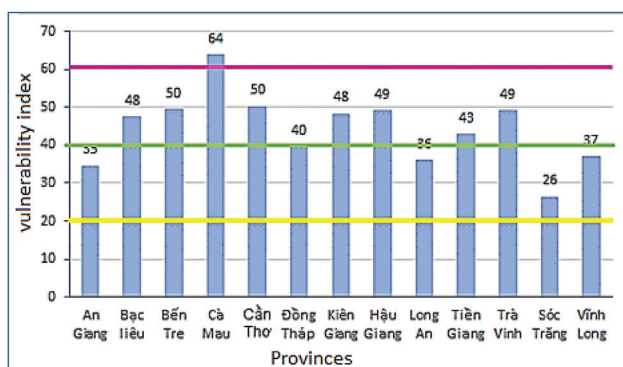


Figure 8. The vulnerability of Mekong Delta provinces by drought

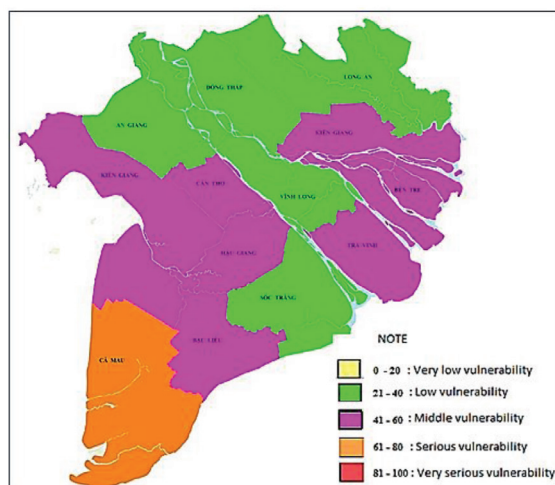


Figure 9. The vulnerable map of Mekong Delta provinces by drought

needs have special and professionally researches about drought impacts which considered in climate change situation

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