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Climate Change Impacts and Adaptation on the Water Resources and Agriculture in Vietnam: Case Studies in Mekong and Red River Deltas

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Water resources and agriculture play an important role in Vietnam. Under climate change conditions, these sectors are considered as the most influenced. This paper aims to review the impacts and adaptations in both water resources and agriculture in two largest river systems in Vietnam: Mekong and Red rivers. A number of water elements influenced by climate change are water flows, flooding situation, saltwater intrusion and water demand for irrigation, as well as a number of agriculture aspects effected are resources and land environment; planting seasons; crops yield; and pest and diseases. This review also presents the adaptation frame for water resources and agriculture in Mekong and Red River Deltas.

1. Introduction

Vietnam is one of the countries influenced by climate change.[1] In particular, the sectors most influenced are water resources and agriculture. Therefore, to response to climate change, it is very important to assess the level of impacts and then propose adaptations in these sectors in the whole country, particularly in two largest Deltas in Vietnam: Mekong and Red rivers.

Water is one of the most important natural resources, which plays a vital role for the existence to all lives on the Earth. Water is reproduced through the time and space. Nevertheless, beside nature, human beings' activities have also influenced to the circulation of water. Vietnam enjoys copious water resources of which two thirds have its origin from the outers. The dry season usually lasts for 6–7 months that causes serious drought to many areas. The pressure of the population bloom, the development of the society, the unreasonable exploiting to the nature as well the climate change impacts have caused negative effects to water resources such as increasing the flood flow, flood flash, the lack of water in dry season, lower level of ground water, decreasing water quality.[3]

Lake water or the flow of water is the most important component in the surface water. Basing on the data measuring from the gauging-stations in Vietnam, the meteorologists have estimated the total average amount of river and lake water in the whole country is approximately 835 billion m^3, of which 522 billion m^3 (62.5%)

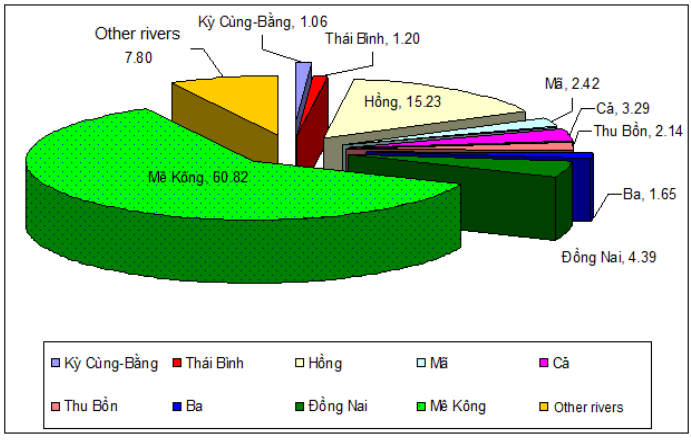

Figure 1 Vietnam river water resources (% over the whole country).[20]

come from the outers, only 313 m^3 (37.5%) is from the inside country (usually called the inner flow). The Figure 1 shows the biggest river water reserves is from Mekong river system, making up 60.82%, and Red river system holds 15.23% comparing to all the areas in the country.[20]

Agriculture is crucial sector in Vietnamese economy with over 70% of the population rely mainly on agriculture. Annually, Vietnam produced 36.5 million tons of rice mostly from two large plains in the Mekong River Delta (MRD) and the Red River Delta (RRD), export from 4 to 5 million tons and ranked the 2nd largest rice export country in the world.[4] However, land area for agriculture in general and rice in particular tends to decrease due to pressure of industrialized and urbanized. The lost rate of land area for agriculture will surely be more serious under climate change condition.

Various projects at the national level have initiated concentrated to respond to climate change and focused on the impacts of climate change on the regions and sectors in Vietnam. However, the published literature review of the ongoing efforts to cope with climate change is still limited. This paper aims to review the impacts and adaptations on water resources and agriculture in Mekong and Red River Deltas.

2. Climate Change Impacts on Water Resources and Agriculture

2.1. *Estimation of the Impacts of Climate Change on Water Resources*

Using the medium (B2) and high (A2) Emission Scenarios of IPCC and sea level rise scenarios,[11] the impacts of climate change on water resources are simulated and assessed on the following specific characteristics: river flows including annual,

flood, dry season flows, flood peak and flooding situation, and saltwater intrusion from the sea in the future. The paper also considered the impacts of climate change on water demand for various sectors, especially water supply for irrigation.

2.1.1. *Annual flow*

The annual flows reflects the total available water resources at various locations of the river systems. Hence, these flows are important parameters for evaluating the adequacy of storage facilities and operation of reservoirs under changes of climate conditions. The impacts of climate change on annual flows varies between regions and river systems across Vietnam.[20]

The impacts of climate change will also increase the annual flow of the Mekong River. According to calculation of the Mekong River Commission,[8] the increase of the average annual flow of the Mekong River in the period 2010–2050 at Kratie and Tan Chau is about 7% and 4% for scenario B2 and 12.5% and 7.6% for the A2 scenario compared to the period 1985–2000. If considering the development of water use and exploitation in the basin, average annual flow in the period 2010–2050 at Kratie and Tan Chau could also increase, but at smaller rate, increasing by only 3.7% and 2.2% for scenario B2 and 9% and 6% for scenario A2 compared to the period 1985–2000.

2.1.1.1. Flow in flooding season. Under the impacts of climate change, flood flow in Mekong River Basin will also increase. Compared with the period 1985–2000, the average flood flow for 2010–2050 under scenario B2 at Kratie and Tan Chau increases by 5% and 2% respectively, and by 11% and 5.8% under scenario A2.[8]

However, for the period 2010–2050, due to reservoir regulation built on the Mekong River (development scenario of water exploitation and use), the average flow in flood season at Kratie and Tan Chau is projected to increase only slightly under scenario A2, at a lower rate of 3.2% and 1.1%, while flood season flows are projected to decrease under scenario B2.

In term of flood peak, the impacts of climate change will increase the risk of flooding with generally increasing of flood peaks and flood volume.[20] On the Mekong River, the maximum daily flow (Q_{max}-day) at Kratie increases in all climate change scenarios during 2010 to 2050. However, the differences between the A2 and B2 scenarios are only significant after 2030. To mid 21st century, Q_{max}-day could increase by over 50% compared to flood peak in 2000.[3]

2.1.1.2. Flow in dry season. Unlike annual and flood flows, flow in the dry season of all rivers within Vietnam will decrease due to the impacts of climate change.[3,20] However, the decreases are quite different between rivers, and are even different between upstream, middle and downstream of one river. In addition, results from the A2 scenario show a greater decrease in dry weather flows than those in the B2 scenario.

2.1.2. *Flooding*

With the impacts of climate change, flood flows and flood peak tend to increase, leading to a greater possibility occurrence of big flood in the future.[5,8,20] The historical flood was simulated with an increasing rate of maximum average daily flow and total flood volume that corresponded to the climate change scenarios for each time period. In combination with sea level rise, the increase in upstream flooding will lead to higher water levels along the river, threatening reservoirs and dyke systems.

For Mekong River Delta, every year in flood season, the Mekong River flood inundates nearly 2 million hectares, lasting 3–5 months. In years with bigger floods, significant human and property losses occur.[8] However, flooding also brings alluvial soils to fertilize the land, abundant aqua-product and good effects in sanitary for rice fields. Large floods in the mid 21st century combined with sea level rise of about 30 cm would increase the flooded area by 25% greater than that of the historical flood of 2000. The flooded areas would occupy almost 90% of all natural area of Mekong River Delta. The flooded areas (>0.5 m deep) would be 2,660,000 ha (accounted for 68.3% area of Mekong River Delta), an increase of 1,160,000 ha (equivalent to 29.5% natural area) compared to the flood in 2000. The flooded area (>1.0 m deep) would be approximately 1,500,000 ha (accounted for 40% area of Mekong River Delta), an increases of 500,000 ha (equivalent to 14% natural area) compared to the flood in 2000.[20]

An increase of flooding in upstream accompany with sea level rise will limit the drainage on Mekong River system and lead to more serious inundation. Consequently, the flooding time will be longer, which can make planting and harvesting of crops more difficult.

2.1.3. *Salinity intrusion*

Sea level will rises an average of 30 cm in 2050 and 75 cm in 2100.[11] This, together with the decrease in water flow from upstream, means that salinity will intrude further into the mainland. The impact of climate change and sea level rise on salinity intrusion in the downstream areas of the river systems was assessed on the basis of calculation by hydraulic models with the upper boundaries being the average flow of the driest month of every 20-year period and with the corresponding sea level rise at each river mouth.

Salinity intrusion will be quite severer for the Mekong River Delta. Over the next 30 years, the area with salinity intrusion at >4‰ is about 1,605,200 ha, occupied 41% area of all Mekong Delta. The area with salinity >1‰ is 2,323,100 ha (occupied 59% area of all Mekong Delta), increasing 193,200 ha compared with present time. In the next 50 years, land use area under salinity intrusion >4‰ is 1,851,200 ha (occupied 47% of natural area of Mekong Delta), larger than baseline (1991–2000) about 439,200 ha. With salinity >1‰, the affected area is

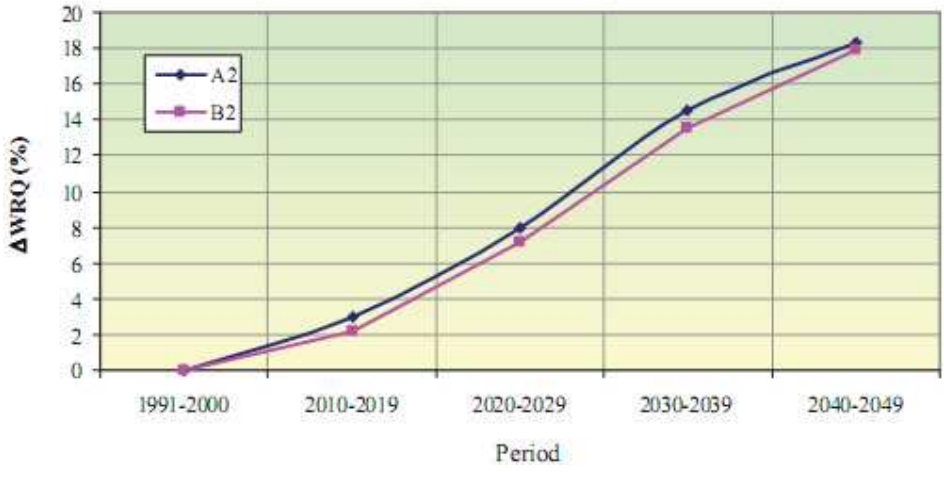

Figure 2 Changes in water requirement for irrigation in Mekong Delta.[3]

2,524,100 ha (occupied 64% of natural area of Mekong Delta), more than baseline about 456,100 ha.[3]

2.1.4. *Impacts on water demand for agriculture*

Temperature rise and the corresponding rise in potential evapotranspiration, together with a decrease in dry season rainfall in all basins, will lead to increase in irrigation water demand. In Mekong River Delta, water demand for irrigation increases up to 18% by 2050 as a result of a low increase in rainfall, combined with a high increase in potential evapotranspiration and a decrease in river flow in the dry season (Figure 2).

2.2. *Estimation of the Impacts of Climate Change on Agriculture*

a. Resources and land environment

According to ADB,[1] if sea level rises from 0.2 to 0.6 m, the land area of inundation will be from 0.1 to 0.2 million ha, consequently, the area of agricultural land will be reduced. If sea level rise of 1 m, about 90% of land area of MRD is flooded from 4 to 5 months. On the other hand, over 70% of land area of MRD is infiltrated salt with concentrations greater than 4% in the dry season. Generally, Vietnam is estimated to lose about 2 million ha of rice land on a total of over 4.1 million ha.[4,7]

- For the Mekong River Delta

Large parts of MRD has high terrain below 1.5 m. Meanwhile, the peak tidal current is generally higher than average water levels from 1.0 to 1.5 m.[2] Under the scenario of climate change and sea level rise in 2100, if the sea level rises 0.69 m

Table 1 The impact of climate change on flood conditions in RRD.[17]

Scenario	Height (m)	Area external of dykes (ha)	Area internal of dykes (ha)	External/internal areas (ha)
	Present			
Completely flooded region	$< -1,5$ m	1 423	2 013	3 436
Semi-submerged region	$< 1,5$ m	24 136	157 781	181 917
	Sea level rise of 0.69 m			
Completely flooded region	$< 0,8$ m	18 576	114 645	133 221
Semi-submerged region	$< 2,2$ m	37 030	263 319	300 394
	Sea level rise of 1.0 m			
Completely flooded region	$< 1,5$ m	24 136	157 781	181 917
Semi-submerged region	$< 2,5$ m	43 433	321 998	365 431

(low emission scenarios - B1) or 1.0 m (high emissions scenario - A1 F1), then tidal peak will swing from 1.7 to 2.2 m or from 2.0 to 2.5 m, respectively. If so, the terrain of MRD is less than the tidal peak from 0.2 to 0.7 m (B1) and from 0.5 to 1 m (A1F1). Thus, coastal areas will be flooded by sea level rise. In particular, during the flood season, due to influence of sea level rise and tide, flood situation will be much more serious, because it is difficult for flood water escape to the sea.[3]

- For Red River Delta

Total natural area of RRD is approximately 1.3 million ha, of which, about 1.15 million ha protected by river dikes and sea dikes. Results to evaluate the effect of sea level rise to RRD terrain is given in Table 1. If sea level rise of 0.69 m (or 1.0 m), areas with altitude less than 0.8 m (or 1.5 m) will be all flooded. This flood areas (including both internal and external of dyke) will increase from 133.221 ha (if sea level rise of 0.69 m) to 181.917 ha (if sea level rise of 1.0 m), and the submerged area also increased from about 300.394 to 365.431 ha.[4,17]

b. Planting seasons

Climate change with the ENSO phenomenon makes increasing frequency of anomalies cold or warm spring anomalies. In the unusually cold spring, most spring wheat will be killed or severely damaged. Also, prolongations of the growth period of grain trees in low temperature conditions will make the grain trees face to epidemics in the late season. In contrast, as less affected by the weather, late spring rice area has increased to 83.7% leading late spring rice production is more stable and higher than that of early spring rice.[16]

Furthermore, climate change will lead the rainfall season and harvesting season to be coincided in RRD, it can make severe damage to rice production and quality. Thus, crop production schedule must change to adapt to weather and climate conditions in order to reduce damages caused by rain and flooding. Specifically, in many places, the time that rice farming season was conducted earlier than the old plan (after 20th June). The shifting cultivation calendar is intended to ensure that the season rice has been harvested earlier in order to avoid damages from

heavy rains. At the same time, the area of paddy land will soon be released for planting winter crops such as corn and soybeans.[16]

c. Crops yield

- For the rice production and yield

The losses of agricultural land due to sea level rise and salination as well as the change of weather and climate are the main cause affecting the yield and quality of crops. According to the Ministry of Agriculture and Rural Development,[7] from 2000 to 2007, rice area has decreased 361,935 ha (approximately 51,705 ha/year), of which, the RRD decreased 52,047 ha, the MRD decreased 205,366 ha. As predicted, the MRD rice area is 1619.8 thousand ha in 2020 and only 993.9 thousand ha in 2050. Consequently, rice production of the MRD reached approximately 18 million tons in 2020, but only 11 million tons in 2050.[12]

Moreover, in recent years, climate change with ENSO and other extreme weather phenomena, especially, warm or cold of spring has affected the productivity and quality of rice. A warm spring with average temperatures of over 20°C will make the young rice become old quickly. It means that the growing time of rice is shorten. Then, rice flowering is earlier than normal about two months with ears of rice are short and less density. Consequently, the rice yield is loosed or even can not be harvested. Examples of warm spring damages are throughout the RRD in the springs of 1991, 1997, 2004. On the other hand, abnormal cold spring such as of the year 2008 caused rice seeds died in early vegetative phase. Moreover, if temperature is too low, the rice reproductive and ripening phases will be prolonged, so that rice plant faces to types of damage pests that usually develops in late season.[14]

Under the average emissions scenario (B2), Vietnam will be taken by about 1.2 million tons/year in 2030 and over 2.16 million tons/year in 2050 (Table 2). So in 2100, if sea level rise of 1,0 m, the rice basket in the MRD will be loosed about 7.6 million tons/year, equivalent to 40.52% of the yield total in area and 21.39% of the yield total in the country.[2]

In addition, climate change causes increasing of saltwater intrusion, flooding, and droughts. For instance, rice yields can be reduced from 17 to 40% if rice land was lacked water due to drought. The increased of CO_2 and temperature will also affect the yield. According to Bao[2], when night temperatures rose 1°C, rice yields would reduce about 10%.

Table 2 Yield and production of food have reduced due to CC (scenario B2).[2]

	2030	2050
Spring rice	1,2 million tons	2,16 million tons
Summer autumn rice	743,8 thousand tons	1475 thousand tons
Corn	500,4 thousand tons	880,4 thousand tons
Soy	84,47 kg/ha	214,41 kg/ha

- For other crops

Similarly, the other food crops such as corn, legumes are reduced due to climate change. As predicted, their yields may be reduced from 500.4 thousand tons in 2030 to 880.4 thousand tons in 2050. Also, the productivity of soybean plants are decreased than the current yield of about 84.47 kg/ha in 2030 and up to 214.41 kg/ha in 2050 (Table 2).

d. Pest and diseases

Climate change influences the living conditions of the creatures that cause to lose and/or change the link in the chain and food webs. This leads to disappearance of some species and increase of pest and diseases. Rising temperatures in winter will create suitable conditions for the worms those can grow faster and stronger harm. Furthermore, climate change also may induce some species, new pests that are not only harmful in production process but also in the preservation of agricultural products and foodstuffs.[13] For example, in two years (2008, 2009), yellow dwarf and twisted leaves epidemic in the MRD affect the ability of intensive farming, increased crop and reduced rice production in some areas. In RRD, in winter-spring of 2007–2008, small leaves deep wound occurred in epidemic. Rice areas were damaged with time up to 400,000 ha, caused significant damage to rice production and increasing production costs. Season in 2009, RRD also began to appear some strange diseases on rice, similar to yellow dwarf, twisted leaves in the MRD.[14]

3. Climate Change Adaptation in Water Resources and Agriculture

3.1. *Climate Change Adaptation in Water Resources*

It is necessary to have suitable strategies and climate change adaptations to reduce bad impacts as well as to increase good effects caused by climate change. The adaptation frame for climate change in river basin water resources consists of these five factors:[9]

- Building a suitable plan for climate change in river basins on social and economic development, forecasting climate change and weather fluctuation within river basins;
- Choosing a set of models that can reproduce hydrographic or agricultural areas in river basins or plains;
- Estimating the impacts of climate change and weather fluctuation on water management by comparing the results of future reproducing with those of the current time, considering the environment and food security;
- Specifying suitable strategies for water resources managers; and
- Estimate the effectiveness of the strategies.

3.1.1. *Adaptations in Red River Delta*

Based on the adaptation frame and considering the specific conditions of Red River Delta, the adaptations in water resources have been proposed. These measures include developing multi-functions reservoir systems; upgrading, building, adding salt preventing constructions in coastal areas; reinforcing, improving embankment and dyke systems; enhancement of afforestation; reasonable and effective use of water; and international cooperation.[10,20]

(a) **Developing multi-functions reservoir systems:** The construction of reservoirs, that ensure flood regulation and appropriate water allocation, can meet the requirements of downstream flood defense in the flood season and water supply in the dry season. This is a traditional measure, but still effective under climate change conditions. There are a number of large reservoirs in Red River basin, namely Son La, Hoa Binh, Tuyen Quang and Thac Ba, and a number are under construction such as Ban Chat and Huoi Quang. In addition, there are many medium and small-scale reservoirs used for agriculture. These reservoirs can be more effective through their optimal operation.

(b) **Upgrading, building, adding salt preventing constructions in coastal areas:** The construction of salinity barriers at the river mouths of Hoa, Do Han and Tra Ly Rivers can moderate salt intrusion in the dry season, and to maintain essential fresh water for primarily domestic and agricultural demands.

(c) **Reinforcing, improving embankment and dyke systems:** Improvement to sea and river dyke systems in the provinces of Hai Phong, Nam Dinh, Thai Binh and Ninh Binh can prevent high flood and sea water intrusion. The existing sea dike systems in the area of Red River Delta are still low and not strong enough to cope with strong typhoons from level 10. Therefore, Reinforcing and improving embankment and dyke systems needs to be implemented in the near future as part of the natural disaster prevention and mitigation program.

(d) **Enhancement of afforestation:** Priority should be given to poor forest or bared areas to protect the soil and retain water flows in the flood season. It is necessary to strengthen the protection of existing forests, especially primeval forests and surface humus layer, acting as a large reservoir to adjust and retain flood flows in the rainy season, and strengthen for the dry season.

(e) **Reasonable and effective use of water:** Reasonable and effective uses of water are recommended for three main using aspects in RRD: agriculture, industry, and domestic. Firstly, RRD is a main area for rice cultivation in the north, which requires a huge amount of water. Therefore, efficient use of water is necessary with priorities adaptations are (i) to continue concreting irrigation channels to minimize water loss, and (ii) to apply advanced water techniques such as drip irrigation. This is very efficient but requires big investment and high technology, so it may be used for specialized concentrated production areas.

Secondly, water use in industry is significant. In the near future (by 2020), Vietnam is expected to be an industrial country with strong development of large industry zones, and therefore industry is expected to be the biggest water user. In company with development, industry might be the main cause of water pollution and quality degradation. Therefore, the following measures need to be applied in order to use water efficiently: Give priorities to reuse of water; treat wastewater from production enterprises to meet the new standards before disposing into environment; and enforce regulations, severely punishing those who do not meet treatment standards.

Finally, water for domestic should be in high quality with two main solutions are to improve the quality of the pipeline system to avoid leakage as well as to monitor regularly the pipeline to avoid illegal extraction of water.

(f) **International cooperation:** International cooperation in the Red River system focuses on strengthening cooperation with China in management and protection of water resources in the upstream areas of Da, Thao and Lo rivers, and reasonable sharing water resources in exploitation and use. It is necessary to have basic agreements on water resources protection in each relevant country, as well as the benefit balance derived from water use for users located at upstream (Chinese part) and downstream (Vietnamese part) areas.

3.1.2. *Adaptations in Mekong River Delta*

Based on the adaptation frame and considering the specific conditions of Mekong River Delta, the adaptations in water resources have been proposed. These measures include completing and reinforcing the approved water conservation projects; construction of sea dyke; salinity prevention; use of fresh water storage measures; environmental protection; and international cooperation.[20]

(a) **Completing and reinforcing the approved water conservation projects:** This measure mainly aims to: (i) avoid flooding and/or increase the flood drain speed; (ii) build and complete the residential areas near the flooded areas and flood control dykes in An Giang, Dong Thap and Long An; (iii) widen drainage canals to west sea (Thailand bay) and to Tien river.

(b) **Construction of sea dyke:** Programming and gradually building dykes along East and West coastal areas to prevent salt contamination in case the sea level rises.

(c) **Salinity prevention:** Preventing salinity intrusion in the dry season need to be implemented, and should include the building of salinity barrier sluices at effective places.

(d) **Use of fresh water storage measures:** Devices such as large jars or pots should be used to store and save rainwater in the wet season for dry season using. The measure has proved to be efficient in coastal areas (Ben Tre, Bac Lieu, Soc Trang,

and Ca Mau) where fresh water from the river is limited in the dry season because of tidal influences.

(e) **Environmental protection:** Environmental protection, including treatment and disposal of wastewater from industrial parks should be monitored regularly and strict punishment should be applied to polluters.

(f) **International cooperation:** International cooperation includes promotion of activities on water resources within the Mekong River Commission. Cooperation focus on sharing of water resources in dry season among riparian countries and construct reservoirs in various locations (within territories of Laos and Cambodia) to store water in flood season for later use in dry season (in downstream).

3.2. *Climate Change Adaptation in the Agriculture Sector*

According to MONRE,[9,10] the adaptation frame for agriculture consists of five factors. These factors include afforestation and forest protection; sensible exploitation of land and water resources for agricultural production; change the structure of plants, animals and the farming practices to consistent with climate change; conservation and development of plants capable of adapting to climate change; and improving propagandizing, training of human resources and international cooperation.

In the Red River Delta, there are several adaptation measures for the agriculture sector. These measures are as follows:

(a) **Water management:**[3,14] Building reservoirs in upstream areas to reduce flood during the rainy season as well as to store, stable water supply for dry season. Simultaneously, upgrading river dyke systems in downstream areas. Building sewer systems and dams to prevent intrusion of sea level rise and mangrove upgrade and improve the bottom drain and sea dykes in estuaries and coastal provinces such as Nam Dinh and Thai Binh.

(b) **Changes of the structure of plants, animals:**[4,12] For plants, seed structure should be changed in consistent with climate change by increasing short-term seeds, or the rice seeds that can stand salt, drought, heat and flooding, with high resistance to pests and diseases.

Rotation crops structural changes: In areas where have not enough water for rice irrigating, rice will be transferred to the cultivation of crops such as corn, peanuts, soybeans and other vegetables those need less water than rice.

Converting to aquaculture: In coastal areas where have been exposed to salt, an effective way for adaptation is to replace cultivation by aquaculture.

For livestock: To create by cross-breeding and to breed animals with high resistant ability to heat and diseases or animals such as cattle, horses, goats, ostriches that their feed is waste from seafood products or from agricultural products. In some areas, water-bird and wild animals such as turtles, tor-

toises, crocodiles, pythons, snakes, porcupine can be reared to replace ordinary animals.

(c) **Investment in new construction, upgrading and modernization of irrigation such as lakes, dams, pumping stations, drainages:**[13,14] The RRD will be upgraded and new built 272 reservoirs, 572 pumping stations to provide water for 398,000 ha of agricultural land. For the targets of 1,162,160 ha, it needs 398 upgrade pump stations, sewer standards and building 143 new works.

(d) **Protection and planting of mangroves:**[13] This is a belt of coastal protection against the effects of storms and sea level rise. It also works to protect sea dikes and ensure the development of biological diversity of plants and animals under the forest. Hundreds ha of mangroves have planted along the coast of Nam Dinh, Thai Binh, Quang Ninh and Hai Phong provinces every year. It is expected that by 2015, Hai Phong will bring the total mangrove area to 6.800 ha (27.7% of the beach) where as Quang Ninh will grow 750 ha of mangroves to create a "green belt" of mangroves in the future.

Similar to adaptation with climate change in the Red River Delta, the Mekong River Delta should also be focused on water management, investment in new construction, upgrading and modernization of irrigation. The specific adaptations are proposed as follows:

(a) **Changes of crop patterns and livestock**: Changes of crops and livestock should be based on planning of land use under the condition of sea level rise. For areas unaffected by tide and salinity, plants and livestock that do not require large amount of water should be applied. In contrast, in areas that recently affected by tide and salinity, the crops and aquaculture should be distributed reasonably and priority for plants and animals that can adapt to brackish and salt water. Also, mangrove forest at coastal estuaries (Ben Tre, Hau Giang and Ca Mau) should be protected and enlarged.

(b) **Rehabilitation and development of rice varieties**[2,17,18] that have ability to face to salinity, droughts, heat and floods as well as have high resistance to pests and diseases. Currently, the new rice varieties that are resistant to high salinity as OM6976, OM6677, OM5464, OM5629, OM5166 have been planted in provinces of Soc Trang, Kien Giang, Bac Lieu, Ben Tre.[19] The rice which can be beard alkaline soil, drought tolerant will be planted in Dong Thap, Tra Vinh and Hau Giang provinces. Moreover, the rice which can grow in submerged conditions will be planted in Hau Giang province.[14,15,16]

(c) **Improving propagandizing, training of human resources and enhancing international cooperation**: Propagandizing to improve community awareness through education and raise awareness and responsibilities of society about climate change. Human resource training is implemented at all levels, sectors and persons involved (managers, planning, program officers, project and

professional staff) in order to develop human abilities to cope with climate change. Finally, agriculture promotes scientific research and international co-operation on climate change, especially within Mekong countries.[4,14,15,16]

4. Conclusions

In this paper, the impacts and adaptations on water resources and agriculture in Mekong and Red River Deltas were reviewed. First, the impacts of climate change on water resources are simulated and assessed on the following specific characteristics: river flows including annual, flood, dry season flows, flood peak and flooding situation, and saltwater intrusion from the sea in the future. It has been found that the impact of climate change on water in flooding season is the most remarkable. In Mekong River delta, an increase of flooding in upstream accompany with sea level rise will limit the drainage and lead to more serious inundation.

Second, impacts of climate change on agriculture in Red and Mekong River Deltas are assessed on land resources and land environment, planting seasons, crops yield, and pest and diseases. In the future, the land area of inundation will be increased because of sea level rise. In addition, land environment is polluted seriously by aluminous and salt in the dry season. Consequently, agricultural land will be reduced. This is a big issue for agricultural development.

Third, the key policies for climate change adaptation in water resources are building a suitable plan for climate change in river basins and specifying suitable strategies for water resources managers. Based on the adaptation frame and specific conditions of Red and Mekong River Deltas, the adaptations are proposed with essential activities are controlling multi-functions reservoir systems at upstream areas and upgrading, building, adding salt preventing constructions at downstream. Finally, in terms of agriculture adaptation, the key policies for Red and Mekong River Deltas are to change the crop patterns and livestock and to investment in new construction, upgrading and modernization of irrigation such as lakes, dams, pumping stations, and drainages.

Because of close relationship between water resources and agriculture, the adaptations are considered in reciprocation. Action plans to adapt with climate change should be divided into different periods, localities, and sectors. For all the economic sectors in general, prioritization of adaptations is to train human resources in order to develop human abilities to cope with climate change as well as to enhance international cooperation on climate change.

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Stakeholder Consultation in Policy Formulation for Climate Change Adaptation and Mitigation: The Experience of Malaysia

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Climate change is cross-sectoral in nature, transcending traditional takes on environmental issues that requires effective collaborative participation and collective response. Stakeholder consultation is, therefore, a crucial component in a climate change policy process. Given the complexities of issues and options, Malaysia developed the National Policy on Climate Change through a consultative process with multiple platforms created for stakeholders of diverse disciplinary constituencies and different interest to interact and share views. Stakeholder viewpoints were gathered in five overlapping phases at national and regional meetings, peer-review sessions and policy level discussions, which provided crucial inputs to the successful culmination of the Policy. While the stakeholders might be at different levels of understanding on the climate change issues, the consultation process also served to sensitise, raise awareness and build capacity of stakeholders to the potential implications of climate change and responses. The consultation process during the policy formulation stage had laid the base and built trust that could be capitalised for continuous engagement of stakeholders during the implementation stage.

Keywords: Climate change, Stakeholder consultation policy formulation, Adaptation, Mitigation.

1. Introduction

Climate change exaggerates stresses on natural and human social systems, prompting response for necessary adjustment. The changes in climate cannot be totally avoided, and is likely to be continuous for many decades and could be more rapid and pronounced than expected (Berkout, 2005). Countries, irrespective of their material standards of living and social and economic development, are potentially vulnerable to climate change biophysically and socio-economically (O'Brien *et al*., 2004). In the context of future climate regime, nations, especially the developing countries, are vulnerable to mandated emissions reductions and potential direct effects from global warming (Buys *et al*., 2009).

The growing concern on climate change calls for multi-disciplinary inputs and responses in various sectors, which combine environmental, social and economic sustainability goals (Kinsman, 2000; Tompkins and Adger, 2004; Darkin, 2006; Sathaye *et al*., 2007; Doria *et al*., 2009; von Storch, 2009). The effectiveness of a policy in reducing climatic risks to natural and human systems relies on a portfolio of diverse adaptation and mitigation actions (Berkout, 2005; Klein *et al*., 2007) of which both are multi-sectoral and cross-disciplinary that need to be dealt with in an integrated manner (Goklany, 2007).

Decision-making about climate change issue is difficult due to the long time frames for impacts to occur and its uncertainties surrounding scientific, economic and governance aspects (Tompkins and Adger, 2005). This prompts the need to explore ways to strategise responses in a collective manner. One important element of successful policies is building broader partnership through inclusion of stakeholder for the effective policy making and implementation (Sankovski, 2000). Governments are increasingly being asked, or required, to involve a broad range of stakeholders in their decision-making processes, especially to consult with stakeholders at early and often, beginning with the formative stages (Gregory *et al*., 2003). Effective and sustained engagement of stakeholders as well as understanding and reflecting their assumptions, values and concerns in framing the policy are necessary but intricate processes (Burger *et al*., 2007). Unless the challenge is met, the objectives of efficient and objective policy design and implementation may be compromised.

In the context of climate change in Malaysia, stakeholders were engaged in the past at project level (for example multilateral and bilateral funded activities) and on specific subject matter (for example the national criteria on clean development mechanism). Most were ad hoc and one-off exercise with simpler objective and confined range of stakeholders. Like many developing countries, climate change is under the portfolio of the ministry handling environmental and natural resource issues. Effective mobilisation of stakeholders is always a tricky task. Such challenges in the policy formulation process were dealt with in order to achieve greater participation and effective elucidation of inputs from stakeholders of multi-sectoral background and interests. Policy formulation itself is one way to achieve mainstreaming of climate change at the country level. The lessons learnt and experiences gained in the formulation process are expected to enhance engagement of stakeholder during the implementation stage.

The development of a national climate change policy forms part of the Policy Study on Climate Change, an initiative under the Ninth Malaysia Plan. The study was initiated by the Ministry of Natural Resources and Environment Malaysia in collaboration with the Institute for Environment and Development, Universiti Kebangsaan Malaysia. It adopted a three-pronged approach, encompassing critical review of national and state documents, comparative studies of international publications, and consultation of stakeholders. This article focuses and shares the experience of Malaysia on consulting stakeholder in formulating the National

Policy on Climate Change. It commences with a review of the motivation and issues associated with stakeholder consultation in policy formulation. This is followed by a contextualisation of Malaysia's scenario that drives the need to develop a climate change policy. The subsequent section delineates the multiple-stage process of engaging the stakeholders that contributed to the culmination of the Policy. The final section is a discussion on the effectiveness of the consultation approach in gaining stakeholder input to finalise the Policy and support its implementation.

2. Stakeholder Consultation in Policy Formulation

Growing environmental awareness and acceptance of deliberative or participative democracy as a key governance mechanism have forced public authorities to introduce new mechanisms for building broader partnerships to national decision-making and policy formulation (Sankovski, 2000; Ananda, 2007; Steyaert *et al*., 2007). Science-based stakeholder dialogues are increasingly emphasised, driven partly by researchers (Welp *et al*., 2006), but also to a great extent due to funding/contractual and regulatory requirements (Winstanley *et al*., 1998; O'Connor *et al*., 2000; Gregory *et al*., 2003; Prager and Freese, 2009), academic endeavour or theoretical inquiry (Steyaert *et al*., 2007; Tompkins *et al*., 2008; Stalpers *et al*., 2009) and general public's demand for greater accountability in science (Welp *et al*., 2006).

Stakeholders are consulted for a number of reasons. One primary objective is to elicit inputs from stakeholders who posses knowledge needed by policy-makers and/or scientists to enhance comprehension and analysis of issue, which would otherwise remain unknown or at least very difficult to access (Welp *et al*., 2006). Such knowledge, mainly the insights and expertise of different societal actors, help in understanding different perspectives of perception and concerns that are crucial to building consensus and reducing potential conflicts (Glicken, 2000; Bardsley and Edwards-Jones, 2007; Steyaert *et al*., 2007). In addition to defining or refining research questions (O'Connor *et al*., 2000; Barlund and Carter, 2002; Aggarwal *et al*., 2004), practical solutions can also be sought to avoid detachment from the 'real world' that may become an academic endeavour with little social relevance (Steel *et al*., 2004; Welp *et al*., 2006). The process of consultation enhances transparency of policy-making, while ensuring scientific integrity, which in turn increases legitimacy and robustness of the solutions (Winstanley *et al*., 1998; Holmes and Clark, 2008). An open multi-stakeholder deliberation is also a mean to deal with the uncertainty of climate change by enhancing ownership and effectiveness of management options through awareness raising and capacity building (Bardsley and Edwards-Jones, 2007). The greater the perception of ownership by agency in policy formulation, the greater the chance of widespread implementation (Tompkins and Adger, 2005).

'Stakeholder' is a relative term that can be defined relative to a particular issue which is, itself, time- and site-specific (Glicken, 2000). A rational discourse in a deliberative process obliges specific rules of participation but do not necessarily include the demand for representation of all possible viewpoints and varieties of opinions (Renn, 2006; Welp *et al*., 2006). Meaningful consultation requires a shared body of essential facts. This is challenging to achieve, particularly in the context of decisions with multiple consequences and significant uncertainties, where participants who understand the subject matter but may have limited expertise in policy making or inexperienced participants may, in good faith, advance proposals that violate principles of good decision making (Gregory *et al*., 2003). Key factors for effective elicitation of inputs are getting the participation right and getting the right participation (Glicken, 2000).

Welp *et al*., 2006 differentiates five types of stakeholder participation based on the roles stakeholders may play as well as the timing and approach of engagement. Policy-makers may invite some people to participate in a process on terms defined by the government (classic paternalistic model) or shift the model toward the consensual type in which 'every affected group participates' to incorporate new kind kinds of information in decision-making (Bear, 1994). While stakeholder dialogue processes do not always aim at being representative of the full spectrum of interests at hand, the consultation approach adopted should link every relevant actor for the problem and be able to provide the opportunity for two-way communication between policy-maker and stakeholders in an iterative process (Glicken, 2000; Renn, 2006; Welp *et al*., 2006).

3. The Prognosis

The average temperature in Malaysia country has been increasing since mid of last century (MOSTE, 2000). Localised climate modelling projected that the country may become warmer by mid and end of the 21st century (NAHRIM, 2006; MMD, 2009). A substantial increase in monthly rainfall over the North East Coastal region of the Peninsular Malaysia and decrease in monthly rainfall in West Coast of the Peninsular Malaysia may be expected (NAHRIM, 2006). Simulated future river flows of several watersheds in East Coast of the Peninsular Malaysia show increases in hydrologic extremes when compared with their historical levels (NAHRIM, 2006). By end of the century, a more significant change in the annual rainfall may be expected in the western regions of Sabah and Sarawak (MMD, 2009).

3.1. *Physical and Economic Vulnerabilities*

The projected changes in climate may result in physical implications to the country. According to the Second National Communication (NRE, 2011), such effects include:

- Lower rainfall that could lead to water shortages for domestic, irrigation and industrial use as well as affect river water quality.
- Higher rainfall may increase the severity of floods in affected areas whilst increasing the likelihood of floods in presently unaffected areas. In addition, higher rainfall intensity will accelerate soil erosion and cause soil degradation, scouring of drainage structures and sedimentation in rivers and reservoirs.
- Changes in temperatures are likely to affect yields of plantations including oil palm, rice, rubber and cocoa as well as transmission of several vector borne diseases.

Malaysia is rich in natural resource. Its economy has over the years inevitably tied closely to its unique resource endowments. While already faced with multiple stressors, the onset of climate change factors may impinge on the sustainable development that rely on climate-sensitive sectors as it compounds the pressures on and alter the distribution and quality of food, natural resources and the environment associated with urbanisation, industrialisation, and economic development. Insights into such potential implications were gained during the preparation of Malaysia's Initial and Second National Communication, where the sensitivity of several key economic and resource sectors was assessed against a range of plausible future climate (MOSTE, 2000; NRE, 2011).

Whilst Malaysia recognises that climate change is a global challenge, which the threats historically stem from developed countries' greenhouse gas emissions, it also faces challenges arose from international socio-political obligations (Buys *et al*., 2009). The total emissions of carbon dioxide tripled from 55.3 million tonnes in 1990 to 177.5 million tonnes in 2004, while per capita emissions increased more than double during the same period (Watkins, 2007). While both carbon intensity of energy and growth in many countries dropped from 1990 to 2004, Malaysia had, on the contrary, shown rising trends in both indicators, exhibiting the carbon inefficiency in energy usage and economic growth. As a rapidly industrialising economy, the country may be required to play a greater role in near future and to face potential trade barriers on high carbon footprint products.

3.2. *Increasing Political Awareness and Technical Capacity*

Further to the ratification of the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, Malaysia established the National Steering Committee on Climate Change for guiding national responses on climate change. Over the years, interests on climate change remained limited at project level including national communication and clean development mechanism (CDM) activities. A survey conducted in 1998 revealed low awareness among general public on climate change with some ordinary Malaysians not even being aware of the existence or functions of the UNFCCC (MOSTE, 2000). Politicians and government officials are more aware of the issue because of their participation

in the negotiation process. It is increasingly recognised that more intense actions on climate change mitigation are necessary due to the discourse on future climate regime, especially since the Bali Climate Change Conference in 2007. With growing concerns on the impacts of climate change after several extreme weather events and natural disasters in 2006 to 2007 in the country, greater need for adaptation was also recognised.

The Ministry of Natural Resources and Environment, as the National Focal Point, has been playing significant role in steering efforts to enhance awareness of different stakeholders through public events held on their own initiatives or in joint force with others. Policy makers from different ministries had organised a series of national and regional conferences in 2007 and 2008 at the behest of the Cabinet of Malaysia (Mazlin *et al*., 2010). In early 2008, a multi-ministerial Cabinet Committee on Climate Change, to be chaired by the Prime Minister, was formed. During the Copenhagen Climate Change Conference in 2009, Malaysia announced that it would voluntarily reduce its emissions intensity of GDP by up to 40% based on 2005 levels by 2020, on the basis of technology transfer and financial support from developed countries. The voluntary aspiration had resulted in a number of initiatives, including the culmination of the Policy being discussed in this paper.

3.3. *Relevant National Initiatives*

Environmental concerns are progressively being emphasised in development plans since the Third Malaysia Plan (1976–1980) (Hezri and Hasan, 2006). Since then, several policies developed by many ministries took environmental aspects into consideration to different extent based on sectoral specific context and needs (Mazlin *et al*., 2010). Although sectoral in nature, these policies also contribute indirectly to addressing climate change (Muthusamy, 2007). The reviews of the Ninth Malaysia Plan (2006–2010) and several national policies reveal the programmes that may directly or indirectly contribute to climate change adaptation and mitigation (Pereira and Tan, 2008). Climate change has yet been mainstreamed into national development plans as the few recent plans only acknowledge the country's active role in multilateral processes. Only until the mid-term review of the Ninth Malaysia Plan recognises specifically, for the first time, the focus of adaptation and mitigation responses (EPU, 2008).

3.4. *Towards Mainstreaming the Issue*

Climate change is a cross-sectoral problem that has wide implications but localised impacts. It requires cooperation from all relevant ministries, state governments and local authorities in planning and implementation (Darkin, 2006). Malaysia will inevitably have to deal with the arising and potential impacts of climate change on the country's development. Immediate responses through both adaptation and mitigation approaches are necessary to reduce the risks and minimise the potential

loss as well as optimise the beneficial opportunities. Furthermore, with growing attention on the annual United Nations Climate Change Conferences, particularly in the face of establishing the future climate regime, Malaysia needs a consolidated strategy to preserve the country's interests in international negotiations.

The existing national policies and initiatives that indirectly address climate change concerns were insufficient to meet the multiple goals of sustainability (Pereira and Subramaniam, 2007). Issues that need to be dealt with are multi-disciplinary and cross-sectoral. The need to formulate a dedicated climate change policy was increasingly recognised in order to mainstream responses on climate change into national policies, programmes and plans.

4. Consulting the Stakeholders in the Policy Formulation

The study adopted a consultative approach in drafting the National Policy on Climate Change. Multiple platforms were created for stakeholders of multi-sectoral and disciplinary constituencies and backgrounds as well as diverse interest to interact with each other and share views. Stakeholder viewpoints gathered at national and regional events as well as peer-review sessions (with selected experts) and consultation workshops (with wider participation) provided crucial inputs to refining the recommendations on the policy. The participated stakeholders had different levels of understanding of climate change issues. The consultation process provided an opportunity to sensitise, raise awareness and build capacity of stakeholders to the potential implications of climate change and responses.

4.1. *Approach*

The whole process of consultation was undertaken in an iterative manner, including the setting of objectives (Gregory *et al*., 2003), selection of stakeholders (Tompkins *et al*., 2008) as well as elucidation, refinement and communication of information (Stalpers, 2009) Strategic principles for the process were established by the study team in consultation with the Ministry and were refined progressively. Objectives of the consultation events organised by the study team were clearly and honestly communicated to the stakeholders. The intention of the policy formulation was communicated and informed to the stakeholders at the early stage and subsequent phases during different forums. Stakeholders from different sectors and disciplines were consulted to ensure concerns are collected and addressed. Communication with stakeholders was treated as a process using different opportunities to facilitate dissemination of information by stakeholders to their own constituencies. Engaging a broad group of stakeholders would enhance the credibility and technical quality of the policy formulated. Potential historical sources of information were traced and reviewed for pertinent inputs. The participatory process was not aimed to seek for validation of predetermined decision, hence no

decision was made prior to a solicitation for input. Feedbacks were provided on how the solicited input were utilised. The outcome of the direct consultations were always circulated or reported to stakeholders, either for review and verification or informing how feedbacks had been considered where appropriate and feasible.

4.2. *Stakeholders*

A stakeholder can be an individual, although individuals generally participate in public processes through groups of individuals with a common interest (Glicken, 2000; Heidrich, 2009). The stakeholder participated in this study were individuals representing an institution and/or a network of institutions. The latter category is mainly existing association or networking of multiple organisations and was given special focus in the study due to the potential for wider outreach, engagement and dissemination of information. The stakeholders were firstly determined from the past activities organised by the study team, while the ministry added the list as and when found necessary. The list was then expanded with recommendations from the engaged stakeholders. The technical experts and researchers working for the government agencies and universities, especially those involving in climate change activities, were the primary target for their 'academic inputs and up-to-date explanation of resources available to the policy formulation (Glicken, 2000). The broad participatory and consultation process in this study enabled the gathering of experience and inputs from the policy-making agencies, non-governmental organisations (NGO) and business and industrial groups for formulating the policy.

4.3. *Method*

To determine how a national policy should be made in anticipation of climate change, the views and opinions of multi-sectoral stakeholders were sought through a combination of direct and indirect approaches. This included rapporteuring, roundtable dialogue and peer-review sessions, open workshops with facilitated discussions, expert meetings, and senior and ministerial levels decision making.

(1) *Rapporteuring*: This approach was adopted to identify key issues of concern and to compile ideas and recommendations expressed by stakeholders in different meetings. Rapporteurs, who are mainly the researchers, lecturers and graduates in the study team, took note of the proceeding of events using template and under guidance of team leader. Information from the presentation and feedbacks provided were summarised and reviewed before being compiled into proceeding that was circulated to the presenters and participants. One best way to reach out to as many stakeholders as possible was to capitalise on national and regional events held in the country during the study period. Most papers presented were sectoral specific issues and generally took stock of past, ongoing and future activities related to climate change,

which became a useful source for up-to-date information in each field. Rapportering the meetings allowed viewpoints to be documented more systematically and minimised the resources that the study team needed to spend on consulting the stakeholders. Many of these meetings were carried out prior to the initiation or during the initial stage of the study. Most of the meetings reports and conference proceedings were published by or prepared with assistance of the study team. Results obtained were used to prepare background materials for guiding stakeholder participation in later events organised by the study team to specifically consult on policy formulation. The inputs were also useful in deliberating the policy framework.

(2) *Roundtable dialogue and peer review sessions*: There may potentially be a number of disagreements among different groups of stakeholder when designing a policy. One fundamental point of conflict was the formulation of the specific policy questions; hence it is important to obtain consensus on the scope and bounds of the issue and the policy questions at the initial stage (Winstanley *et al*., 1998; Welp *et al*., 2006; Steyaert *et al*., 2007). We engaged technical experts and policy makers of multiple sectors in two dialogues to shape and refine the policy-relevant questions and potential consultation approac. The first roundtable dialogue provided a platform for scientific and policy debates among agencies having diverse missions and perspectives, which broadly supported to address both adaptation to and mitigation of climate change in a balanced manner as well as highlighted the need to engaging stakeholders (Raja Zaharaton *et al*., 2008). The second one was an expert session to peer-review the background information and to obtain inputs on principles for guiding the process of policy formulation as well as the policy itself. Besides deliberating the possible institutional arrangement to support implementation of the policy, many proposed sectoral response measures gathered by the study team were refined by the experts.

(3) *Workshops with facilitated discussions*: The workshops were organised to directly seek stakeholder viewpoints, initially on the policy framework and followed by the details of the policy. In addition, it was a mean for verifying inputs sought in the preceding sessions. A total of five consultation workshops were held over a year. The first three events targeted specific groups including the NGOs, business and industrial representatives, and the second national communication project members (representing the technical experts). The other two meetings gathered all different groups and sectors of stakeholders. All workshops were organised in similar fashion: a presentation to brief about the draft framework or policy followed by facilitated discussion sessions. The participants were informed about the study background, approach in policy formulation, results obtained to-date as well as objectives and expected outcomes of each workshop. Facilitators were selected to play the mediating role in ensuring all perspectives were heard. Experienced individuals who were familiar with the subject matter and recognised for their expertise were, as far

as possible, chosen from outside the study team. In some cases researchers of the study team were employed either because of their familiarity with the background of participants or extensive experience in moderating dialogue. In both cases the facilitators were able to effectively motivate participants' inputs, clarify questions and summarise discussions. More inputs, particularly sectoral-specific key actions, were gathered while the draft policy was refined further each time through the workshops.

(4) *Expert meetings*: Careful balancing on a case-by-case basis was necessary when considering the incorporation of varied agendas from different sectors and disciplines into the policy. A number of meetings involving a group of experts or one-to-one discussion with specific expert were organised by the study team or the ministry. Most meetings were held at the later stage of the policy formulation process, especially after the three focus group workshops. The draft policy was refined in terms of the organisation of the contents, expression of texts and specific measures recommended. The meetings helped finalising the draft policy before submission for decision making.

(5) *Decision making*: This process involved three levels of deliberation, including the senior officials within the ministry, dissemination and commenting by other ministries as well as the cabinet ministerial meeting. Once the draft policy was finalised at the expert level, senior officers including the minister held several meetings to proof-read and fine-tune the document. It was then circulated to other relevant ministries for policy level review and no substantial comment was given. The policy was then deliberated in the Cabinet Meeting, consisting of ministers of all ministries, and approved in end 2009.

4.4. *Process*

The stakeholder consultation was carried out in five overlapping phases. In the first two phases of consultation, the need for a national policy on climate change was articulated and emphasised on most occasions. In Phase 3 and 4, the policy framework, including its key actions, was strongly supported and welcomed as a promising tool to mainstream climate change in national development. In the last phase, the drafted policy was refined by experts, reviewed by the ministries and finally approved by the Cabinet in end 2009. The key features of each phase of consultation are summarised in Table 1.

Phase 1 focused on documenting viewpoints obtained from eleven meetings over a period of four years, from 2005 to 2008. The eleven meetings involved about 1150 participants. The main objectives of this phase are to identify key issues of concern and compile ideas and recommendations expressed by stakeholders in different meetings. Many of these meetings were carried out prior to the initiation or during the initial stage of the study. Most events covered general issues that were relatively less technical. However these events were critical for being introductive and providing information on the roles potentially played by each of

Table 1 Summary of the stakeholder consultation process.

Phase	1	2	3	4	5
Duration	2005–2008	2007–2008	2008	2008–2009	2009
Objectives	• Identification of issues. • Compilation of ideas and recommendations.	• Communicating the policy formulation process and preliminary outcomes. • Awareness raising	• Soliciting inputs on policy framework. • Seeking of guidance and endorsement by national committee and national focal point.	Soliciting inputs on draft policy.	Finalisation and approval of policy
Approach of consultation	Indirect (reviews of conference proceedings)	Direct (presentation of study approach and preliminary outcomes)	Direct (workshop and official submission)	Direct (workshop, official submission and expert meetings)	Direct (senior official meetings and Cabinet meeting)
Number of event	11	7	7	6	4
Types of event	• Project specific preparatory/inception and consultative meetings. • Capacity building initiatives. • Awareness raising, and sharing of information and experience.	• Project specific initiation and consultative meetings. • Awareness raising, and sharing of information and experience.	• Peer review and consultation workshops. • Policy and senior level briefing and consultation.	Consultation.	Consultation.
Level of stakeholders	National and state.	National and state.	National.	National and state.	National.
Number of stakeholders	About 1150.	About 400.	About 130.	About 170.	About 50.

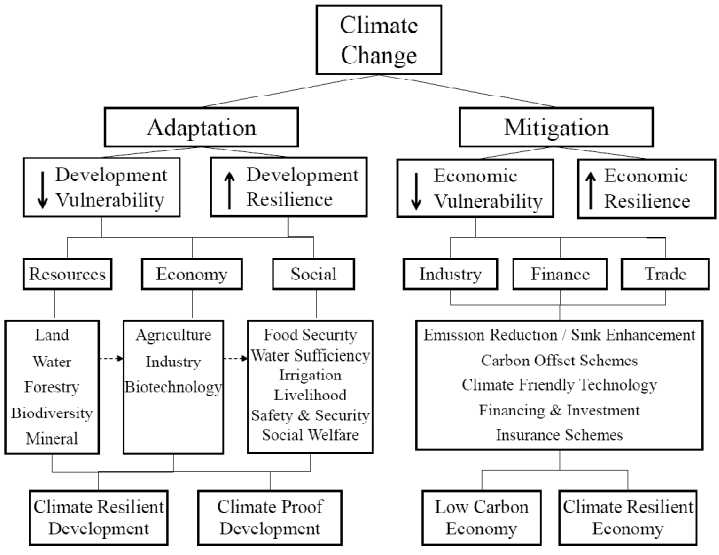

Figure 1 Overall framework of a national climate change policy.

the presenting agency. This state-of-the-art information provided an opportunity to take stock of past and present activities based on credible source while avoiding duplication and fill gaps. Most of the meeting reports and conference proceedings from these events were published by or prepared with assistance of the researchers from the study team. Some critical viewpoints were encapsulated in Tan *et al*. (2009).

Stakeholders were informed about The initiative in developing a national policy on climate change on some occasions, but consultations were undertaken indirectly in this phase. The inputs gathered served as the basis for developing the policy framework (Figure 1), which seeks to balance adaptation and mitigation.

Phase 2 focused on keeping the stakeholders informed on the policy formulation. There were seven meetings involving about 400 participants held in 2007 and 2008. Some events were project-specific initiation and consultative meetings, while others mainly aimed to raise awareness and provide a platform for sharing of information and experience. Researchers of the study team presented to the stakeholders about the approach undertaken in formulating the policy and preliminary results obtained. Proceedings of the meetings are either not prepared or unavailable. However, through the interactions the stakeholders expressed their support to a national policy on climate change. Inputs gathered from these meetings served to consolidate the policy framework.

Phase 3 involved the presentation of the proposed policy framework to obtain direct feedback from about 130 stakeholders in seven consultative meetings. The stakeholders were approached through peer review sessions and consultation

workshops. The stakeholders supported the development of a dedicated national policy on climate change, which would encompass principles, strategic thrusts and key actions. The need for strengthening existing institutional arrangement was stressed and the effectiveness of programmes must be ensured through monitoring of indicators or appropriate mechanism. As the climate change will cause localised impacts, local level participation is highlighted. Based on the feedbacks, key actions were formulated and improved. Results of these consultative meetings were occasionally presented at the senior level briefing sessions with the Ministry in seeking for policy guidance and endorsement, while also soliciting inputs.

When this phase of consultation was conducted, the government had just established the Cabinet Committee on Climate Change in early 2008 with the aim to coordinate cooperation from all relevant ministries, state governments and local authorities in the planning and implementation of climate change responses. Therefore, one of the main issues in the consultation was deliberating the structure, compositions and functions of several sub-committees to be established to support the cabinet committee. This is a crucial aspect to the policy formulation as the drafted policy is expected to be implemented through the institutional arrangement s created.

Phase 4 involved the scrutiny of the draft policy and key actions by about 170 stakeholders, including the state governments of Sabah and Sarawak. Two national consultation workshops and state level meetings were held to solicit stakeholders' viewpoints and inputs on the Draft National Policy on Climate Change. The stakeholders agreed that the national policy on climate change should steer for mainstreaming of climate change measures, integration of balanced adaptation and mitigation responses, and strengthening of institutional and implementation capacity. Prioritisation is needed on enhancing the country's adaptive capacity to actual or expected impacts of climate change. Nationally appropriate mitigation actions should be approached to enhance adaptation and sustainable development. Stakeholders also agreed that concerted holistic responses is necessary as climate change impacts transcend all levels, sectors, stakeholders and major groups, whilst effective collaborative participation, grounded on indigenous and scientific knowledge should serve as a mainstay for institutional capacity building. The policy will facilitate the integration of climate change considerations in development and decision-making processes, to foster sustainable economic and human development as well as environmental conservation. It should also complement existing policies and takes into consideration international conventions on global concerns. The Draft Policy consists of several key elements that include objectives, principles, strategic thrusts and key actions, and is aimed at ensuring a climate-resilient development and low carbon economy that fulfils national aspirations for sustainability.

During Phase 5, which was the last phase of the consultation, the Draft Policy had been finalised at the 'operational' level and sought the final approval at the ministerial level. Within the ministry several meeting were carried out to fine-tune

and proof-read the document before it was distributed to other relevant ministries for comment. Feedbacks received contain no substantial alteration on the Draft Policy. This might be attributable to the fact that the officers from most ministries had been consulted through the earlier sessions. The finalised policy was then submitted to the Cabinet and was approved in November 2009.

5. Discussion and Conclusion

Climate change is a complex issue affecting various sectors that requires integrated responses from multidisciplinary actors. This article described the iterative approach of consulting stakeholders in the formulation of Malaysia's National Policy on Climate Change. Multiple platforms were created for stakeholders of multisectoral and disciplinary constituencies and backgrounds as well as diverse interest to interact and share views. The stakeholders, including government bodies, research institutions, private groups, NGOs and academics, were selected from various sectors and expanded to cover wider players. The viewpoints gathered provided crucial inputs to drafting, refining and finalising the Policy.

The policy formulation was timely given the rising political awareness due to the international negotiation processes as well as the increasing technical capacities attributable to relevant activities initiated by the government and through multi- and bilateral funds. Building on such background, the strategic consultation process had effectively contributed to the adoption of the Policy with no major obstacle. The participatory approach facilitated consensus building among stakeholders of different constituencies as well as at the ministerial and cabinet levels. Among all, one major achievement was the opportunity of participation by the NGOs that had recommended repeating similar approach in other policy process. While the participated stakeholders might be at different levels of understanding on the climate change issues, the consultation process also served to sensitise, raise awareness and build capacity of stakeholders to the potential implications of climate change and responses.

While the Policy will play its crucial role in steering the country's responses to climate change, it is equally important to ensure that it is adaptive to changes in information about climate science and understanding of the future climate during implementation stage. The Policy needs to prepare for both anticipated and unanticipated conditions to avoid inappropriate response capacity is built (Tompkins and Adger, 2005; IISD & TERI, 2006). One way to achieve that is to continuously engaging stakeholders who may support in different role during the implementation stage. Even before the actual implementation, the participatory approach should be sustained to allow stakeholders deliberate detailed plan of actions, especially an appropriate monitoring and review mechanism. The stakeholder consultation process during the policy formulation stage had laid the base and built trust that could be capitalised for continuous engagement of stakeholders

during the implementation of the National Policy of Climate Change. While the government agencies will be the main implementers, engaging the stakeholder enables more effective and efficient role-play by each constituency: the private sector to implement regulated measures or enhance creativity in implementation; the NGOs to become watchdog and provide feedbacks; as well as the research institutions and academia to conduct research to support knowledge-based decisions.

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Climate Disasters and Climate Change in Vietnam: Tendency, Strategic Tasks, and Action Plans

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This paper explores climate disaster trend and reviews strategic tasks, and action plans for the different periods, regions and sectors to respond to climate disasters and climate change in Vietnam. Climate disasters in Vietnam will significantly change in quantity and intensity. For tropical cyclones, their frequency is not clear trend but strong typhoons increase in both frequency and intensity. This review presents a number of strategic tasks, and action plans for the different periods, regions and sectors to prevent, response and mitigate climate disasters and climate change in Vietnam.

1. Introduction

As a peninsula in the monsoon tropical Southeast Asia, Vietnam is specified as one among nations with a high potential of being influenced by negative impacts of climate change.[1,10,15] In fact, Vietnam has already been experiencing manifestations of climate change in terms of fundamental climatic elements (temperature, precipitation etc.) as well as extreme weather phenomena (storms, heavy rains, droughts, etc).

In recent years, under the impact of climate change, the frequency and intensity of climate disasters is increasing, causing enormous losses of human lives, property, infrastructure, economic, cultural and social impact on the environment.[14,15,19] Only in the last 10 years (2001–2010), the types of climate disasters such as tropical cyclones, floods, flash floods, droughts, salinity and cold fronts have done significant damaged. More than 9,500 people have been killed and missed, and property lost at around 1.5% GDP per year during this period.[19]

Understanding the negative effects of Climate Disasters and Climate Change on the National development, the Vietnam Prime Minister approved three very important Decisions (No. 172/2007/QD-TTg, No: 158/2008/QD-TTg, No. 2139/QD-TTg) in order to prevent, response and mitigate climate disasters as well as climate change. This paper aims to explore climate disaster trend and presents strategic tasks, and action plans for the different periods, regions and sectors to respond to climate disasters and climate change in Vietnam.

2. Climate Disaster Tendency

Climate disasters in Vietnam such as floods, flash floods, droughts, heavy rainfall[2] will increase in quantity and intensity where as drizzling rain, cold front; cold days significant decrease; frequency of tropical cyclones is not clear trend but strong typhoons increase in both frequency and intensity.[6,14,22,24] Although cold days and damaging cold days decrease, extremes cold fronts are appeared more frequency.[12,14]

2.1. *Tropical Cyclones*

Change in frequency of tropical cyclones effecting and/or landing Vietnam is not clear.[7,8,14] The Figure 1 shows the number of tropical cyclones acting in East Sea (Blue line), influenced (grey line) and landed (cobalt blue).

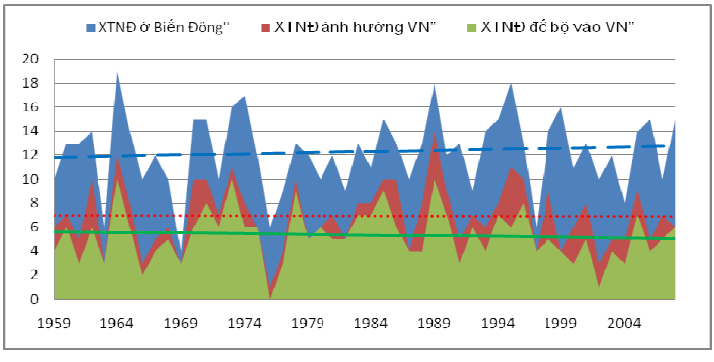

Figure 1 Trends in tropical cycles in East Sea, effecting and/or landing in Vietnam over the past 50 years (1961–2010).[8]

However, climate change may lead to abnormal in frequency of very strong typhoon, the patterns and directions, landing areas, and season. Maximum wind speed of very strong typhoon can reach 250 km/h with minimum air pressure at the centre of 910 hPa in Chanchu, for example, which occurring from 13th to 18th May 2006. More and more complex track with landing area are moving toward southern and storm season moving to the late of years.[8]

2.2. *Cold Fronts*

Frequency of cold front in the North decreases significantly in the past three decades.[8,13] However, extreme cold fronts appeared more frequently such as a recorded cold spell which consecutively lasts 38 days during January and February, 2008 in Northern causing extremely and damagingly cold weather.[13]

2.3. *Floods and Inundations*

In recent years, climate disasters which due to flood and flash flood occur more frequently and caused serious damage to people and property occurred repeatedly in recent years. According to MONRE,[8] the number of serious flash flood in the four last decades 1970s, 1980s, 1990s and 2000s are 7, 8, 103 and 87 respectively.

As two largest deltas in Vietnam, Red and Mekong River Deltas are often influenced by floods.[3,13,20] With regards to the Red river, annual flow has descending trend, but strong flood events have appeared more frequently. Mekong delta, on the other hand, consequences of strong floods occurring in 2000, 2001 and 2002 with crest of flood at Tan Chau being over 4.5 m showed a increase of undetermined in hydrological extremes caused by climate change.[20]

2.4. *Droughts*

Under the influence of climate change the drought situation becomes harsher and harsher, more complex and occurs more frequently with uneven level among zones, stations in each climate zone.[3,8,9,12] Dry seasons in 2009–2010, 2010–2011 witnessed serious drought appearing in North Delta, South-Central zone, Central Highlands, South zones, and Mekong river Delta. Especially, dry situation and deficient water were manifested the most clearly in Red river Delta in dry season of 2010–2011 with water level, discharge, and water reserves in reservoir at different positions having minimum levels in observed periods.[3,14,20]

Another remark is change in drought season. Usually, droughts mainly concentrate on most of winter and early spring months. However, in the late 10 years (2001–2010), droughts occurred even in the rainy season months for examples in 2002, 2004, 2006 and 2009 in Central Highlands, South, and South Central zones.[8]

3. Strategic Tasks

3.1. *Strategic Tasks of Climate Change*

The Prime Minister of Vietnam approved the **National Climate Change Strategy** with strategic tasks for climate change, listed as follows:[19]

3.1.1. *Proactively respond to climate disasters and climate monitoring*

a. Disaster risk reduction: This task will review and formulate development planning and construction regulations in disaster-prone areas in the context of increasing disaster incidents due to climate change; reinforce and develop key, imperative disaster preventive structures.

Capacity building for professional rescue teams, which is the core factor in the close collaboration between rescue forces for proactive response in case of

emergencies. Implement specific measures for effective disaster prevention, especially for flash flood and landslide in mountainous areas, with long-term effective maintenance and operation.

Enhance forest functions against disasters, desertification, invasion, and land degradation by strengthening forest quality, covering barren land with trees, and promoting the efficient use of forest; In the coastal areas, it is important to protect, managing and developing mangroves and wetland ecosystems as a belt for disaster prevention.

b. Climate monitoring: Construct and operate an effective climate change and sea-level rise monitoring system which will be expected to complete in 2015 for constructing the flood, disaster risk and climate maps according to the climate change and sea-level rise scenarios. At the moment, a project at ministry level named "Building an early climate warning system for Vietnam" has been implemented.

Modernise the hydrometeorological observation network and forecasting technology to guarantee the forecasting and early warning of weather extremes. Targets by 2020 are to (i) have a developed hydrometeorological observation network with a station density in line with developed countries and (ii) strengthen the telemetric system to ensure continuous monitoring of weather, climate and water resource variations to provide suitable data for new hydrometeorological forecasting technologies and other demands. By 2050: accomplished an observation, forecasting, warning system with international standard.

3.1.2. *Food and water security*

Food security emphasizes on land used, high biotechnologies. Land resource in each area will be maintained and exploited reasonably and sustainably under climate change conditions, it means that crops and livestock should be adjusted to adapt to the climate change, sea-level rise and the local natural conditions. For example, in areas unaffected by tide and salinity, plants and livestock that do not require large amount of water should be applied. On the other hands, for areas recently affected by tide and salinity, the crops and aquaculture should be distributed reasonably and priority for plants and animals that can adapt to brackish and salt water.[21,24] Finally, modern biotechnologies includes pest and disease control will be researched, developed and applied on agriculture production processes in order to get high productivity.[4,5,25]

Water security concentrates on water management capacity building, and international cooperation. A set of database on water resource variations, water quality and water usage as well as a completed set of regulations to enforce efficient, integrated, multi-purpose development and use of water resources will be established and developed in order to provide basic information for water management. Also, a set system of irrigations, hydropower plants and embankment will be improved, reinforced and constructed to effectively cope with floods, droughts, sea-level rise, and saltwater intrusion in climate change conditions. International cooperation

focus on research, evaluation and control of water quality and quantity, and transboundary benefit sharing.

3.1.3. *Positive response to sea level rise consistent vulnerable areas*

In the first place, assessments and predictions of impacts and vulnerability of areas, sectors and communities to sea-level rise are important to provide necessary information for developing a master plan for socio-economic development in time of climate change, especially under increase of floods, inundations, saltwater intrusions, droughts, land loss, and environmental degradation in sensitive areas, including Mekong River Delta, Red River Delta, Central Vietnam's coastal areas, and marine biodiversity reserves.

Strengthen residential infrastructure and planning to respond to climate change. In coastal zones and island areas, which considered as the most vulnerable places, need to be improved deteriorated parts of sea and river dykes for minimum protection against storms of scale 9 and tidal frequency of 5%. In other places such as urban, residential, and industrial zones, it should be prioritized to develop large-scale multipurpose structures, water reservoirs, buffer zones and green belts.

3.1.4. *Protection and sustainable development of forest, increasing carbon absorbabilities and biodiversity conservation*

Enhancement of afforestation: Accelerate the progress of forest projects such as afforestation, reformation, and encourage the business to invest in economic forestation. Priority should be given to poor forest or bared areas to protect the soil and retain water flows in the flood season. It is expected that by 2020, the forest coverage increases to 45%.

Increasing carbon absorbabilities and biodiversity conservation: Develop and implement GHG emission reduction programmes through efforts to stop deforestation and forest degradation; retain and increase carbon sinks in association with maintaining and diversifying local livelihoods adaptive to climate change. For conservation of biodiversity, resilient ecosystems and species with highly endangered to climate change should be protected.

3.1.5. *GHG emission reduction to protect global climate system*

Development of new and renewable energies by increasing research and development of renewable and new energy generation technologies, include wind, solar, tide, geothermal, bio and cosmic energies; developing policies to encourage stakeholders' participation in the promotion of renewable energy use. In the future, increase the share of new and renewable energies by 5% of the total commercial primary energies by 2020 and 11% by 2050.

Energy saving and efficiency by restructure the economy toward reducing energy-intensive industries and create incentives for sectors to reduce energy consumption. It should be developed and implemented incentive policies for energy efficiency in economic sectors, especially transportation, urban development, industry and agriculture.

Alter the agricultural practices by using reasonably water, fertilisers and feeds; management and treatment of livestock waste; using biogas as a fuel; elimination of old low-efficiency agricultural tools. Accelerate green production in agriculture, reduce emission, ensuring sustainable development and national food security and contributing to poverty alleviation; after every 10 years, reduce 20% of the GHG emission, while securing 20% of the sector growth and lowering the rate of poverty by 20%.

Solid waste management by having solid waste management plan. Target by 2020 is 90% of the urban household solid waste to be collected and treated, of which 85% to be recycled, reused and recovered for energy generation.

3.1.6. *Community capacity development to effective respond to climate change*

Communities responding to climate change: Build community capacity and increase community involvement in climate change adaptation activities, with an emphasis on local coping experience and the role of the authorities and local communities. Develop and diversify local livelihoods for flexible adaptation to different level of vulnerability.

Raising awareness: Educational programmes contain climate change sciences. Particularly, develop suitable approaches to disseminating climate change information to different communities; use a variety of media to disseminate the impacts, risks and opportunities of climate change to people, especially in the vital areas.

3.1.7. *Scientific and technological development for climate change response*

Development of scientific and technological is key task for climate change response. The priority sciences focus on climate change management, evaluation, monitoring, and impact prediction to socio-economic development, healthcare, production and consumption. Survey and basic scientific research and application of adaptive and GHG emission reduction technologies should be implemented parallel to technology transfer and effective application of scientific achievements and modern technologies.

In the future, new fuels and materials are applied for GHG emission reduction and climate change adaptation; It is necessary to encourage the competitiveness of

economic sectors communities to use modern technologies to move forward low-carbon and green growth.

3.1.8. *Strengthening international cooperation and integration to enhance the country's status in climate change issues*

Another important task is to strengthen partnership with other countries and international organisations in the implementation of the UNFCCC and relevant international agreements. International cooperation also promotes activities on the essential sectors such as water resources, agriculture, especially within the Mekong countries. Gather international climate change information and focus on collaborative monitoring activities, and share information on trans-boundary to ensure mutual benefit of countries.

Simultaneously, the government take proactive role in development of multilateral and bilateral agreements and treaties on climate change. Review and strengthen the legal framework, policies and mechanisms to concur with the international rules and agreements on climate change in which Vietnam take part.

International support is mobilised: develop and apply financial mechanisms that suit the international climate change policies to mobilise and use effectively bilateral, multilateral financial aids for climate change response. Increase the management and coordination in using domestic and international financial resources for climate change response in a focused and effective manner, prioritising urgent projects. Encourage domestic and international organisations and individuals to provide financial assistance to climate change response.

3.2. *Strategic Tasks for Climate Disaster Risk Reduction*

National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 was approved by the Prime Minister (Socialist Republic of Vietnam, 2007) shows strategic tasks as follows:[17]

a) Consolidate the system of laws, policies and mechanisms: This is general task for formulating the Law on natural disaster prevention and response based on the existing Ordinance on Flood and Storm Control, suiting the national socio-economic development. Promulgate policies on disaster relief and recovery for each region: living with flood, flood diversion and retention, flash-flood and landslide vulnerable areas etc.

Law, policy and mechanism system need to integrate natural disaster prevention, response and mitigation into social-economic development planning and plans. While producing plans, zonings and conduct disaster risk assessments to formulate suitable policies for each region, locality, and critical zone, it is compulsory to stipulate criteria and technical instructions of construction in disaster prone areas and to stipulate policies to encourage research activities, investment attraction, international cooperation, and resources mobilization for disaster management.

Consolidate organizational structure by (i) strengthening the leading bodies of disaster management at ministries and sectors, and at both central and local levels, (ii) professionalizing the staffs for disaster prevention, response and mitigation, (iii) upgrading working places for steering agencies/bodies in the field of disaster prevention, response and mitigation at all levels with appropriate equipments and technologies, and (iv) encouraging to establish organizations of supporting disaster management, coaching and training centers, and public services for disaster prevention, response and mitigation.

b) Development and social mobilization of human resources: Local residents are directly involved disaster prevention, response and mitigation. Socialization policies in which favourable conditions are created for the participation of local residents in formulating legislation, plans and programs, as well as in managing and monitoring the implementation of local programmes and projects. Besides, increase the training of the human resource to meet requirements for disaster prevention, response and mitigation, especially human resources for relevant advisory and administration agencies.

Human ability is raising by promoting disseminating information, education, awareness which include basic knowledge about natural disaster prevention, response and mitigation into school curriculum to help children know how to respond to and support their family and community in disaster situations. Trainings also provide for those who are directly involved in disaster prevention and mitigation, especially for decision-makers, managers, planners, practitioners, and local officers.

Encourage national and international organizations and individuals to develop diverse and efficient ways of support for disaster affected people and areas. Particularly, to organize self-response forces and to develop volunteer networks in communities for active emergency search and rescue in order to promote the role of social organizations and associations in disaster response and recovery.

c) Financial resources: The State budget must ensure the investment for natural disaster prevention, response and mitigation projects and the reservation for disaster relief and recovery. The reserved state budget can be used for disaster prevention, response and mitigation if necessary. Take advantage of ODA and FDI for disaster prevention and mitigation projects, giving priority of non-refundable ODA utilization for capacities strengthening and technological and management experience transfer.

Gradually increase the annual budget for strengthening the management capacities, implementing new construction projects, upgrading and maintaining structures. For projects of planning, improving equipment and facilities for disaster forecast, warning, rescue, relief, recovery and production rehabilitation, the State decentralizes to People's Committees of provinces and districts in investment and mobilization of legitimate resources. Also, the State has policies

to provide preferences and to protect legitimate interests of organizations and individuals investing in disaster prevention, response and mitigation.

The State encourages national and international organizations and individuals to invest in researching and applying science and modern technologies in combination with traditional methods as well as to join in finance activities or conduct humanitarian and charity activities for disaster affected localities.

d) Develop science and technologies related to natural disaster prevention, response and mitigation: Similar to climate change issue, the scientific and technological development is key task for natural disaster prevention, response and mitigation. It promotes basic investigation and investment for scientific research and new technology application: modernize early warning systems from Central, regional to local levels, focusing on efficient communication methods especially for remote areas like mountainous or coastal areas.

The State encourages the application of advanced scientific and technological achievements to improve capacities of disaster prediction, warning, and communication. Step by step develop scientific sectors related to disaster: emergencies, disaster management, sustainable development, health care, post-disaster environmental and production recovery.

e) Ensure safety for dyke, reservoir and dam systems: For long-term and sustainable development, river and sea dyke systems must be built, strengthened and upgraded to meet the design standards, and be suitably used for multi-purposes of social-economic development. System's upgrading focus on enhancing quality of dykes, preventing dyke degradation, and reducing the number of weak sections on dyke foundation and sluices underneath the dykes. An effective way is to harden of dyke surface to serve as rural traffic or to plant trees as a protection belt.

Regularly inspect and evaluate the situation of the existing reservoirs for repairing, upgrading and newly building emergency spillways to ensure safety for reservoirs. The reservoirs' operation procedures for multi-usability should be considered and completed, particularly in cases of large reservoirs involving to regulate water levels in flood and dry seasons.

f) Enhance the search and rescue capacities: Search and rescue are prompt actions for disaster reduction with the high demands of the local capacities. Thus, it need to be enhanced the search and rescue capacities of specialized and semi-specialized forces and local people by regularly organizing exercises of disaster prevention, response and mitigation at all levels and localities. It is important to improve disaster emergency information, communication and on-site response capacities for local organizations, individuals, and communities especially for those in mountainous, remote and border regions, and islands.

g) Promote international cooperation and integration: Boost regional and international cooperation in terms of disaster warning, forecast, education, training and technology transfer, information sharing, experience and practical lessons to

build up agreements, and conventions for disaster prevention, response and mitigation, especially for emergency search and rescue. Cooperate with international organizations to implement the UN Convention for Climate Change, the Kyoto Protocol, Hyogo Framework for Action and other programmes. Work in collaboration with countries in the region on water resources exploitation, protection and management.

4. Action Plans

4.1. *Action plan for climate change*

Action plans to response to climate change[18] as well as focused on implementing the National Target Programs up to 2020 for reducing climate disaster risks will be divided into different periods. This review, however, presents the **priority programmes up to 2015:**[19]

a) The National Target Programme to Respond to Climate change, development of extended plan for 2016–2025;
b) The National Scientific Programme on Climate Change;
c) The Hydrometeorological Observation Network and Forecasting Technology Modernisation Programme by 2020;
d) The water resources management and climate change adaptation programmes for Mekong and Red River Deltas;
e) The GHG emission inventory, reduction and management of emission reduction activities;
f) The climate change response programme in megacities;
g) The sea dyke and river embankment upgradation and reinforcement programme under climate change and sea level rise conditions;
h) The public healthcare improvement programme in the in climate change and sea level rise conditions;
j) The socio-economic development programme in inhabited island to cope with climate change and sea level rise;
k) The pilot programme for community's effective response to climate change with an aim for further expansion.

4.2. *Action Plan for Climate Disaster Risk Reduction*

National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 Focus to implement the following target programs up to 2020 (Socialist Republic of Vietnam, 2007):[17]

a) The program on improvement of legislation and policies: This will promulgate (i) the Law on disaster prevention, response and mitigation, (ii) disaster relief and recover policies, supporting the environment and production

rehabilitation after disaster, (iii) assistance policies for disaster prone areas. Simultaneously, establish financially self-reliant fund for disaster prevention, response and mitigation and implement disaster risk insurance in some sectors.

b) The program on consolidation of organizational structures: This annually strengthens the steering mechanism, provide training courses to enhance capacities for staff working in the field of disaster prevention, response and mitigation, and establish organizations supporting disaster management.

c) The programme to make and review plannings: Define and map areas highly prone to flash floods, river and sea erosion, storm, earthquake, sea level rise, tsunami. Map out the flood areas to assess risks of flood and drought. These fields are reviewed and amended as follows: the flood prevention control plannings and river/sea dyke system plannings; the residential plannings in flash flood and landslide-prone mountainous areas and in erosion prone areas along riverbank, river mouth and coastal areas; the land use plannings to link with disaster prevention and control; plannings to protect and develop mangrove forests for sea dyke systems and in coastal areas; the construction plannings in disaster prone areas; the integrated exploitation and management plannings of river basins.

d) The programs on strengthening of disaster warning and forecast capacities: The warning and forecasting capacities in terms of storms, floods, earthquakes, droughts, salty intrusion, and tsunami should be strengthened in the areas of Red River Delta, Mekong River Delta, rivers in the Central region, Central Highlands and the Eastern South of Viet Nam.

e) The programs on community awareness raising: Information/knowledge/experience on disaster prevention, response and mitigation should be provided to communities living in disaster prone areas by training, disseminating via mass media, and even including in the school programmes.

f) The programs on forestation and protection of upstream forests: Focus on the development and exploitation of the economic value of forest products in the areas of protection forests to benefit local people, this will encourage them in forestation.

g) The program on strengthening of disaster management capacities: Strengthen capacities for disaster management agencies from the central to local level, and for search and rescue forces by reviewing and adding construction standards appropriate to the natural disaster characteristics in each region, and establishing volunteer networks for natural disaster prevention, response and mitigation.

h) The program on science and technology application: Apply scientific and technological advances as well as new techniques and materials for natural disaster prevention, response and mitigation. Improve information and communication systems and management of boats/ships at sea.

i) The programs on strengthening of constructions: This programme focuses

on to review, upgrade and newly build structures matching the designed standards and each region's disaster characteristics. The programme includes the improvement of reservoirs, erosion prevention structures, dyke systems, storm shelters for boats and ships and residential clusters for flood and storm avoidance.

5. Implementation Result Analysis

Ministry of Natural Resources and Environment has developed and published the first edition of climate change and sea level rise scenarios for Vietnam in 2009, which proposed Ministries, sectors and localities to use medium scenario as initial orientation for assessing the impacts of climate change on each field and developing the action plans to respond to climate change. The second edition scenario with higher resolusion has been published in 2012 and the third version which follow up the 5th Assessement Report of IPCC (AR5 of IPCC) will be finished by 2015.

Based on the climate change and sea level rise scenarios, Ministries, sectors checked, developed, amended the development plans of sectors, fields in order to respond to climate change and climate disasters, specifically as follows:[23]

For plannings: Fulfilment of the irrigation master plan for Mekong river delta, Red river delta, Central region; flood prevention planning for big cities such as Ho Chi Minh, Hanoi, Can Tho, Hai Phong; checked the planning, finished the sea embankment system from Quang Ninh to Kien Giang; checked the planning of salinity forests which can be recovered and become new protective forests in the coast of Vietnam; made plan to improve embankment, dike in the important areas nationwide.

Ministry of Natural Resources and Environment checked the water resources planning of big river basins; developed and submitted to the Prime Minister for promulgation of the operation procedure of A Vuong, Dak Mi 4 and Tranh river 2 joint reservoirs, Son La, Hoa Binh, Thac Ba and Tuyen Quang joint reservoirs in the flood season every year; implemented the project of forecast technology modernization and hydrometeorology monitoring network.

Ministry of Industry and Trade made the National electric power development master plan; Checked hydrography master plans in combination with provinces; proposed the mechanisms and policies to encourage the development of electricity from renewable energies such as wind energy, solar energy, in order to gradually increase the percentage of renewable energy in the structure of energy supplies.

For developing the scientific and technological programme: Developing the framework of scientific and technological programme as the basis for implementing science research to serve the development of regulations, policies and action plans to respond to climate change in Vietnam.

For strengthening capacity for interdisciplinary activities: Developing and promulgating "Framework guiding development of action plans to respond to climate change for Ministries, sectors and localities" for Ministries, sectors and localities to study, develop and implement action plans to respond to climate change of Ministries, sectors and localities.

For raising awareness and developing human resources: Minister of Natural Resources and Environment has actively coordinated with Vietnam Television, Radio the Voice of Vietnam and other public media to increase time limit, content and regularly renovate forms of communication on climate change.

Ministries, sectors have actively developed, implemented many communication activities to improve awareness of officials in the sector and community, with diverse contents, mentioning each specific field. Typically, Ministry of Information and Communications has edited, published the manuals on climate change for reporters and editors; Ministry of Education and Training started to implement the training and education on climate change in the education programmes at all levels.

Through communication activities, by now awareness of organizations, individuals, enterprises and the society of climate change has clearly improved. Most of residents become aware of negative impacts of climate change through negative weather, natural disaster, flood, major cause of which is human sense which has affected and made the climate system change.

6. Conclusions

Under the impact of climate change, climate disasters in Vietnam such as floods, flash floods, droughts, heavy rainfall will increase in quantity and intensity where as drizzling rain, cold front; cold days significant decrease; frequency of tropical cyclones is not clear trend but strong typhoons increase in both frequency and intensity. Although cold days and damaging cold days decrease, extremes cold fronts are appeared more frequency.

The National Strategic Tasks and Action plans for the different periods, regions and sectors have been ratified strategic tasks for climate change, of which, the three most priorities are *food and water security*, *scientific and technological development*, and i*nternational cooperation and integration to enhance the country's status in climate change issues*. Food and water security directly relate to agriculture and water resources that are two essential economic sectors in Vietnam. Where as scientific and technological development, and international cooperation are short and effective ways to cope with climate change.

In terms of climate disaster risk reduction, general strategic tasks including: Consolidate the system of laws, policies and mechanisms; Consolidate organizational structure; Socialization of disaster prevention, response and mitigation

and human resource development; Ensure financial resources for natural disaster prevention, response and mitigation; Community awareness raising; Develop science and technologies on the natural disaster prevention, response and mitigation; Ensure safety for dyke, reservoir and dam systems; Capacity building for salvage and rescue; Promote international cooperation and integration

Action plans to response to climate change as well as focused on implementing the National Target Programs up to 2020 for reducing climate disaster risks will be divided into different periods, localities, and sectors. The priority programmes for 2011–2015 for climate change response should be implemented Currently, the official climate change and sea level rise scenario has been published to provide basic information for Ministries, sectors local communities in order to respond to climate change and climate disasters.

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Mitigation Co-Benefits of Adaptation Actions in Agriculture: An Opportunity for Promoting Climate Smart Agriculture in Indonesia

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The government of Indonesia has been promoting the system of rice intensification with emphasis on resource use efficiency and climate change adaptation benefits. One question remained to be seen is how the system of rice intensification compares with other technologies such as zero tillage, composting, and leaf color charts which have also been advocated for resource conservation, climate change adaptation and mitigation benefits. In this paper, we made an attempt to quantify the mitigation co-benefits of various agriculture technologies and compared them with the system of rice intensification through marginal abatement costs and cost benefit analysis. The analysis has indicated higher mitigation potential for the system of rice intensification compared to other technologies in question. However, zero tillage provides least marginal abatement cost and higher returns per dollar invested and hence could be a better choice. When assessed for the nationwide mitigation potential, system of rice intensification provides greater mitigation potential compared to other technologies.

Keywords: Co-benefits, Adaptation, Mitigation, Indonesia, Synergistic agriculture.

1. Introduction

Agriculture plays an important role in the national economy and food security of Indonesia. Increasing food production, while not adversely impacting the climate and local environment, is a challenge to be met. Indonesia has set an economy-wide emission reduction target of 20%. This would require rapid and substantial scaling up of mitigation technologies in agriculture sector as well. However, being a developing nation and vulnerable to a range of climate change impacts, the country also need to focus on adaptation aspects in its response to climate change. Meeting both adaptation and mitigation goals could pose challenge to the country with limited resources necessitating a synergistic approach to the problem. Such a synergistic approach is possible by considering both mitigation and adaptation goals while prioritizing mitigation and adaptation technologies from the context

of policy focus. Estimation of marginal abatement costs and cost-benefit analysis of various agro-technologies could provide a means of meeting the both ends. The paper has identified that there is a considerable potential for the country to promote those adaptation technologies that have significant mitigation potential (and vice versa). The major barriers for expanding these technologies have been lack of proper incentives for technology adoption and capacity building of farmers. The best way to enhance the efficiency of a technology is to target it to the specific ecosystem conditions. While focusing on individual technologies, there is a need to consider how these technologies behave in the existing context of knowledge and infrastructure on the ground. This paper was drafted based on the outcome of the consultation meeting on low carbon development organized in Bogor, Indonesia[1] literature review and assessments made by the authors which were discussed in the consultation meeting.

2. Need for Synergistic Approach to Climate Change in Indonesia

Indonesia is an agrarian economy with agriculture contributing to 13.8% of national GDP in terms of value addition and employs 38% of Indonesian population.[2] The government of Indonesia has made serious efforts to improve the food self-sufficiency and nutritional security over the past decade. As a result, the national expenditure on agriculture rose by 11% per year from 2001 to 2008.[3] Despite the rising investments in agriculture, Indonesia is still a net importer of cereals, pulses and sugar and is facing the challenge of hunger and malnutrition with nearly 38% of its children suffering from under weight and malnutrition. Indonesia is classified as 'serious' in Global Hunger Index (GHI) by IFPRI.[4] Indonesia has a GHI of 12 in 2012. In comparison, Thailand has a GHI of 8.1, Malaysia has 5.2, and India has 22.9. Hunger index, whose values range between 0 to 40, combines three equally weighted indicators of hunger namely undernourishment, child under weight and child mortality. For more details on Global Hunger Index, please refer to the IFPRI report on Global Hunger Index, 2012.

2.1. *As a Vulnerable State to Climate Change Impacts*

The climate change brings another dimension of challenges to the Indonesian agriculture both due to its vulnerability to climate change impacts and as a contributor to the greenhouse gas emissions.[5] Past climate observations and available climate change projections indicate that Indonesia is highly vulnerable to climate change impacts.[6,7] The historical analysis of climatic data has indicated a significant increase in maximum and minimum temperatures across most of the stations in Indonesia along with associated sea level rise.[7] Past trends also indicated the presence of changes in precipitation, incidence of extreme temperatures and dry spells associated with a clear influence of decadal cycles of El Niño and

La Niña. However, the trends were not uniform across the Island nation. For example, significant reduction in December-January rainfall was observed in parts of Sumatra, Java and Papua while an increase in precipitation was observed in eastern Indonesia including parts of Bali and Nusa Tenggara Barat. Despite the limitations in the availability of good quality projections for Indonesia region, the available projections indicated a similar trend as that of the historical trends (e.g. increased wet days in Bali and Nusa Tenggra). Though conclusive evidence is not yet available on projected negative impacts of climate change on crop production, analysis presented in Indonesian National Communications indicate change in wet and dry spells and seasonal precipitation patterns along with the influence of El Niño could largely pose serious threat to the Indonesian agriculture.

2.2. *As a Contributor of GHG Emissions*

In addition being vulnerable to climate change impacts, Indonesia also contributes to climate change in both direct and indirect means. As a direct source, Indonesian agriculture contributes to about 6% of total greenhouse gas (GHG) emissions and the sector stands fifth after land use, land use change and forestry, fuel combustion, and waste sectors (Las and Unadi, 2010; see Figure 1). The major contributors of GHG emissions in agriculture sector are rice paddies (Methane emissions to the tune of 34,860 $GgCO_2e$), soil fertilizations (nitrous oxides emissions to the tune of

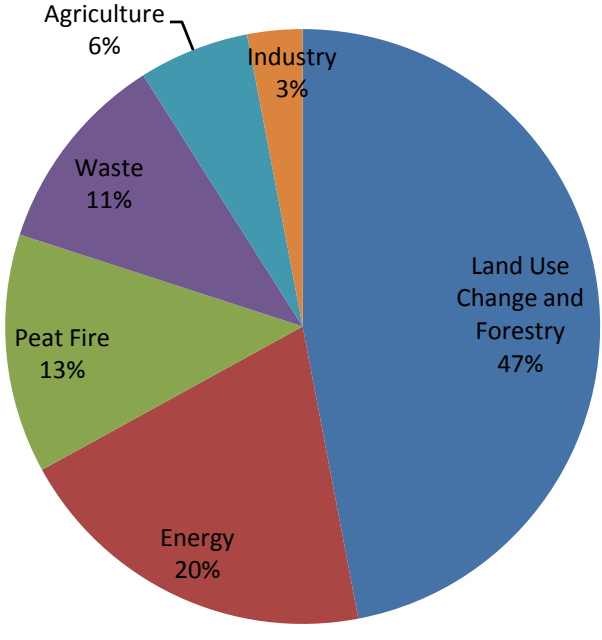

Figure 1 GHG emissions from various sectors in Indonesia.[5]

15,534 $GgCO_2e$), and other minor sources such as emissions from manure piles, biomass burning etc (to the tune of 12,271 $GgCO_2e$).[8]

Land use changes: The indirect contribution of agriculture to GHG emissions is through demand for land. The growing population exerts pressure on food that in turn exerts pressure on land and other sources forcing intensive cultivation practices such as fertilizer applications and irrigation water pumping. In a scenario of increasing population, the agriculture is expected to produce more food either through vertical expansion (increase in productivity) or through the horizontal expansion (land use changes from forests to agricultural purposes). In Indonesia, both these phenomenon can be seen in the recent past. The productivity levels of Indonesian agriculture have increased over the years and more specifically in food crops such as rice. The rice productivity has more than doubled over a period of 40 years,[9] mostly due to employment of high yielding varieties, irrigation, fertilizers, and pesticides. At the same time, the cereal demand during the past four decades has also increased from 10 million tons in 1961 to 39 million tons in 2005.[10] In order to meet this demand, over the same period, the area under primary crops has increased by 113% and the area under agriculture has increased by 25.6% while the area under forests has reduced by 38% in the last two decades alone.[11] This partially indicates that agriculture has played a role in converting the land under forests to agriculture in Indonesia. This is in conformity with the trend observed in the Southeast Asia (Figure 2; Prabhakar, 2010; and FAO, 2010) and corroborates to that of the land use change trends presented in the Second National Communication submitted by the Government of Indonesia.[7]

Changing food preferences: Indonesia is a major non-vegetarian population. With growing income levels, the per capita consumption of animal products is also

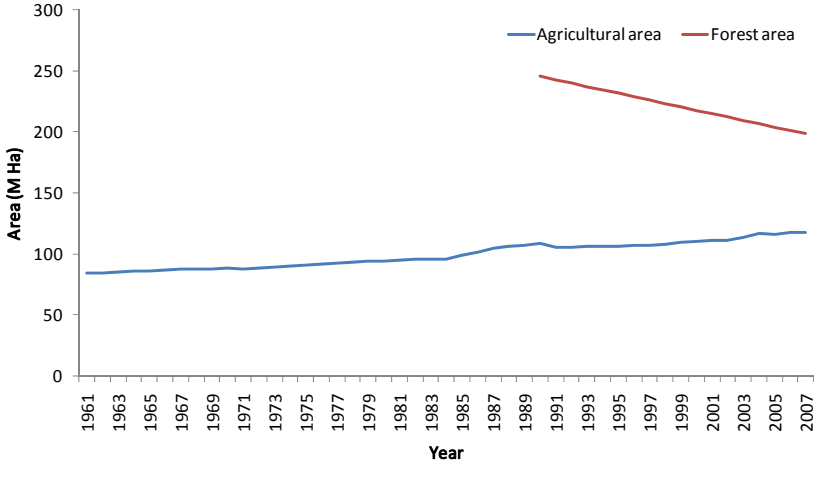

Figure 2 Expansion of area under agriculture with concomitant decline in area under forests in Southeast Asia.[11]

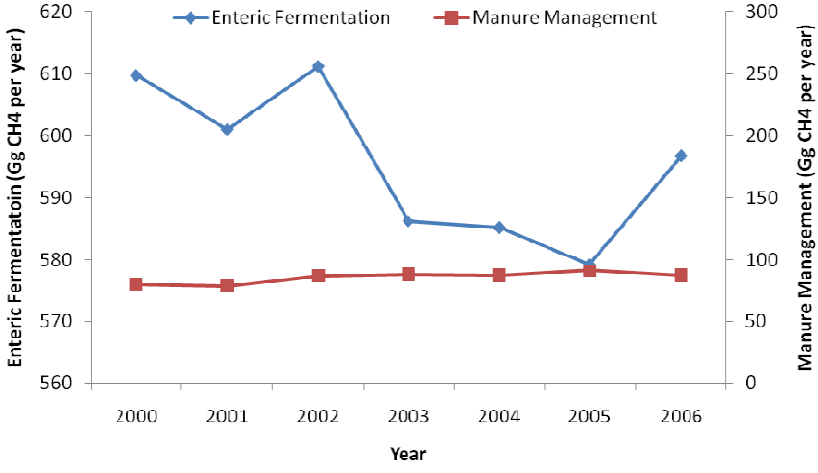

Figure 3 Indonesian Methane Emission (Giga Grams, Gg) from Livestock in 2000–2006.[8]

increasing over the years. As a result, the emissions from animal husbandry are significant in Indonesia. The enteric fermentation contributes to the tune of 12,755 $GgCO_2e$ of methane annually. As shown in Figure 3, the animal husbandry related emissions have shown an increasing trend since 2003 owing to relative increase in animal population.[8]

Other contributing factors: There are several other trends that would enhance emissions from agriculture sector in the future, if unhindered. These trends include from forces operating within the sector and outside the sector. Within the agriculture sector, changes in the source and amount of on-farm energy consumption, reducing organic matter application, and burning of paddy straw. Though the energy related emissions, including the energy used in farming, are accounted in the energy sector, the policies and interventions for reducing on-farm energy should have to come from the agriculture sector and hence it deserves particular attention in the discourse on GHG mitigation in agriculture. Trends such as increasing farm mechanization associated with rural to urban migration of population, increasing monoculture, and increased groundwater pumping for irrigation can have significant impact in terms of on-farm direct energy consumption. In terms of indirect energy consumption, the declining organic matter inputs in soils necessitate increasing inorganic fertilizer use resulting in demand for crude oil. In addition, expansion of cash crops such as oil palm is projected to increase demand for fertilizers in Indonesia.[12] Other forces include those of increasing population pressure on agriculture that limit the choice to certain forms of agriculture with high GHG emissions, increasing deforestation and related land use changes converting to agriculture and non-agriculture uses of land with limited carbon sequestration possibilities.

If no corrective measures are taken, the above trends may continue in the future as well. Most available future projections indicate that the non-CO_2 emissions will continue to increase in agriculture sector at global and regional levels[13,14,15] and projections for Indonesia indicate an increase in agricultural emissions from 0.17 $GtCO_2e$ in 2005 to 0.25 $GtCO_2e$ by 2020. Methane emissions from the animal husbandry sector in a BAU scenario indicate similar increase in GHG emissions.[8] This suggest that Indonesia need to undertake substantial efforts for it to limit the GHG emissions in the near future and ignoring agriculture sector would not help it in reaching the objective of mitigating GHG emissions.

3. Synergistic Agriculture for Indonesia

From the foregone discussion, it is can be concluded that aspects such as historical and current agro-economic situation, the observed and future projected emissions from agriculture, and climate change vulnerability pose a challenging task of mitigating GHG emissions while meeting the food security needs of the growing population of Indonesia. From this context, the low carbon society for Indonesian agriculture means producing sufficient food for the country to meet the food and nutritional security while not degrading the environment and not contributing to the climate change. As simple as it may look, the task could be difficult looking at the food and nutritional insecurity of the country.

Solving the above puzzle requires Indonesia identifying and promoting agro-technologies those will satisfy the following conditions: 1. provide yield and income advantages contributing to rural development and national food security, 2. provide significant GHG mitigation advantage, and 3. Facilitate the above two at lower costs. One of the means to attain these benefits is through focusing on the synergistic agriculture, the form of agriculture that provides significant increase in food productivity and production, and reduce GHG emissions at least possible costs. Hence, promoting synergistic agriculture in Indonesia require a two-pronged approach that identifies and scales up GHG mitigation technologies that do not impact the food production, and putting in place an enabling policy environment that helps in scaling up of these synergistic agro-technologies.

3.1. *Current State of Synergistic Agriculture in Indonesia*

Low carbon agriculture is not a new concept for Indonesia since it has been implementing various policies to promote low input and organic agriculture over the past decade. Much of these policies were driven primarily not because of climate change but due to environmental degradation and food safety issues.[16,17] To site an example, the agriculture input subsidies that have been in existence for long time have been known leading to the fertilizer imbalance, pesticide overconsumption and decline in factor productivity. As a result, Indonesian government

has been actively promoting organic agriculture as a low-input and eco-friendly agriculture. One of the significant programs to mention is the 'Go Organic 2010' program by the Government of Indonesia that aims at developing Indonesian organic agriculture as significant organic food exporter in the world. A roadmap has been developed to achieve the set goals. As a result, the area under low-input and organic agriculture has been growing at a steady rate, with an estimated area of 17783 ha in 2005.[18] However, several limitations including poor availability of organic fertilizers, poor access to agro-technology, and high cost of organic certificationare hampering the rapid expansion.

As a part of its initiative to promote environmentally friendly agriculture, the government of Indonesia has made significant investments in promoting the system of rice intensification (SRI), the technology that is known to save irrigation water, reduced seed rates, bring early crop maturity, and significantly increase the rice yields.[19] Various other technologies are also being promoted which include Implementation of no-burning practices for land clearing in particular in horticulture and agriculture plantation sub-sectors, introduction of low methane emitting rice varieties (Ciherang, Cisantana, TukadBelian and Way Apo Buru), use of agriculture waste for bio-energy and composting, biogas technology for reducing methane emission from livestock sector, and formation of R & D Consortium on Climate Change in Agricultural Sector. Several of these programs have been implemented through the '*Bantamas*' program.[5] Though there are no statistical figures available on the extent of adoption of these technologies, the ongoing engagement with various stakeholders by authors of this paper indicate significant efforts being invested by both the government and the non-governmental organizations in the spread of these technologies using farmer field schools and climate field schools with limited success in adoption rates.

A speech delivered by the Indonesian President at the Conference of Parties 13 at Bali, Indonesia, outlined a three-pronged strategy to rejuvenate Indonesian agriculture sector.[5] This includes harmonization of economic development and environment conservation, to boost the capability to absorb carbon in forest, agricultural land, and ocean, and a commitment to reduce greenhouse gas emissions in various policy initiatives. The development of agriculture sector was identified as a general strategy with both adaptation and mitigation built into it. Indonesia is the only developing country in East Asia that has announced an ambitious economy-wide mitigation target of 20% at Copenhagen. This includes a reduction of 8 $MtCO_2e$ through the support of the national budget and an additional reduction of 11 $MtCO_2e$ through the support of developed counties. The focus for agriculture sector includes food crops, estate crops, livestock, land and water management, and R&D. The plan proposes to undertake 5 main activities and 1 supporting activity for mineral soils and 2 main activities and 1 supporting activity for peat lands. The plan proposes to spend an estimated 0.7739 trillion USD for GHG mitigation from mineral and peat lands.[5]

3.2. *Prioritizing Synergistic Technologies for Indonesian Agriculture*

The research in Indonesia and elsewhere has already identified several technologies with the potential to mitigate GHG emissions in agriculture (Table 1) and animal husbandry (Table 2). These technologies have already been either developed or are being adopted by farmers, indicating that there is no dearth of mitigation technologies in agriculture and animal husbandry. However, what is lacking is a strategy to prioritize these technologies and creating enabling environment to promote enabling policies in an aggressive manner.

Having identified a list of technologies, the next step is to prioritize these technologies for wider dissemination and adoption, both through the government driven policy initiatives and by the individual players. As discussed earlier, such a prioritization should not only consider GHG mitigation potential but also consider yield and income advantage to the farmers. This is possible through employing methods such as marginal abatement cost curves, benefit-cost analysis, and abatement cost per unit production.

Table 1 List of agro-technologies that have mitigation benefits.[20]

Technology	Major benefits
1. Zero-tillage	1. Zero-Tillage saves 70–90 L of diesel/ha. 2. Saves water (to the tune of $\sim 1.0 \times 106$ L water). 3. Farmers save USD 40–55/ha. 4. Reduced/ eliminate burning of crop residues.
2. Leaf color charts	1. Reduced N applications and hence reduced demand for fertilizers. 2. Reduced pest incidence. 3. Yield advantages.
3. System of rice intensification with mid-season drainage	1. Saving in irrigation water. 2. Higher yields. 3. Reduced pests and diseases. 4. Reduced labor costs. 5. Higher income.
4. Aerobic composting	1. Doest contribute to CO_2 emissions. 2. Eliminates CH_4 and N_2O emissions. 3. Considered as a natural cycle.
5. Alternative nutrient management strategies through altering sources	1. Slow releasing fertilizers such as coated urea granules and super granules has the potential of reducing leaching losses and increased N use efficiency and reduced N usage. 2. Neem coated urea/sulfur coated urea/tar coated urea formulations that inhibit nitrification leading to less N_2O emissions.

Table 2 List of mitigation technologies that are either currently at adoption or development stage in Indonesia (adopted from Suryahadi and Permana 2010).

Techniques	Methane reduction (%)	Feed efficiency	Animal production	Strengths	Weaknesses
Dietary Supplementation					
1. Unsaturated fatty acid	10	Increase	+15%	Local product Simple application.	Needs scaling up and in limited supply.
2. Probiotic (Yeast)	8	Increase	+9	Local product Easily adoption.	Needs scaling up and in inconsistent results.
3. Concentrate	8	Increase	126	Easily adoption Simple application.	Limited supply.
4. Fish oil + Zn	54	Increase	+61.2	Local product.	Needs scaling up and in limited supply.
5. Ionophore Salinomycin	Decrease	Increase	+26.6%	Advanced Technology Effective.	Limited supply, imported product, and poisonous.
6. Mineral bypass nutrients	Decrease	Increase	22%	Local product.	Need diffusion action.
7. Defaunating agents	Decrease	Increase	+20%	Local product Abundant Simple application.	Inconsistent result and needs maintenance.
8. Urea molasses block	Decrease	Increase	+6%	Simple application Advanced technology.	Need extension program.
9. Leguminous	Decrease	Increase	Increase	Local resources Simple application.	Limited plantation, limited use, and poisonous.
Mechanical and chemical techniques					
1. Chopping and Pelleting	Increase	Increase	Expensive	-	Cumbersome
2. Sodium hydroxide	Increase 10–20	Increase	Expensive	Simple	Poison
3. Ammonia	increase	Increase	Expensive	Simple	Poison

3.2.1. *Marginal abatement cost (MAC)*

Marginal abatement costs refer to the cost incurred in mitigating a unit of carbon (equivalent) emissions when compared to the business as usual scenario (Equation 1).[20]

$$\mathrm{MAC} = \frac{M_c}{M_{\mathrm{GHG}}}; M_c = C_a - C_b; M_{\mathrm{GHG}} = \mathrm{GHG}_a - \mathrm{GHG}_b;$$
$$\mathrm{GHG}_a = \mathit{Activity} \times \mathrm{Ef} \times \mathrm{Sf} \quad (1)$$

Where MAC is marginal abatement cost ($\$t^{-1}$); M_c is the marginal cost of the new technology when compared to the baseline technology; M_{GHG} is marginal reductions in GHG emissions; C_a is cost of technology a; C_b is cost of technology b; GHGa is GHG emissions from technology a; and GHGb is GHG emission from technology b. Activity

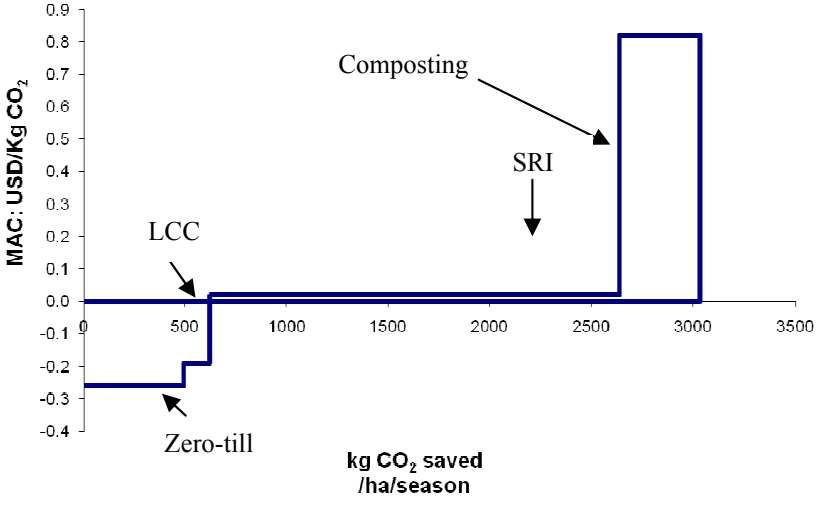

Figure 4 Marginal abatement costs of various technologies for Indonesia.[20]

refers to activity data (e.g. area under particular technology or amount of biomass burnt or amount of particular fertilizer type used); Ef refers to emission factor, factor that provides GHG quantity by multiplication with the activity data; Sf refers to scaling factor, factor that modifies a sub-practice from the base line practice (e.g. intermittent irrigation as against continuous flooding).

The analysis carried out by authors indicated that the SRI has higher potential for abatement (2016 kg CO_2e per hectare per season followed by the zero-tillage systems (450 kg CO_2e per hectare per season; Figure 4). Zero tillage has negative costs since adoption of technology saves on tillage and fuel costs while SRI could prove costly due to labor intensiveness of operations and need for investing in precise water control operations. These per hectare benefits can be multiplied several times depending on the adoption rate of these technologies. As an example, Figure 5 shows the cumulative GHG mitigation benefits of expanding all the technologies depicted in Figure 4 to the entire paddy area in Indonesia. It shows that SRI provides highest mitigation potential when compared to other technologies. The cumulative benefit could be as much as 37.3 Mt CO2e per annum which is 49.5% of the total GHG emissions in 2000 (75.42 MtCO_2e).

3.2.2. *Benefit-cost ratio*

The benefit-cost ratio (BCR) refers to the ratio of total benefits obtained per unit of cost incurred in mitigating GHG emissions (Equation 2). Various costs considered for calculating the BCR for technologies depicted in Figure 4 are listed in Table 3. The field data on actual benefits and costs were obtained by interviewing paddy farmers in the village Jambenengan located in the Kebon Pedes sub-district of

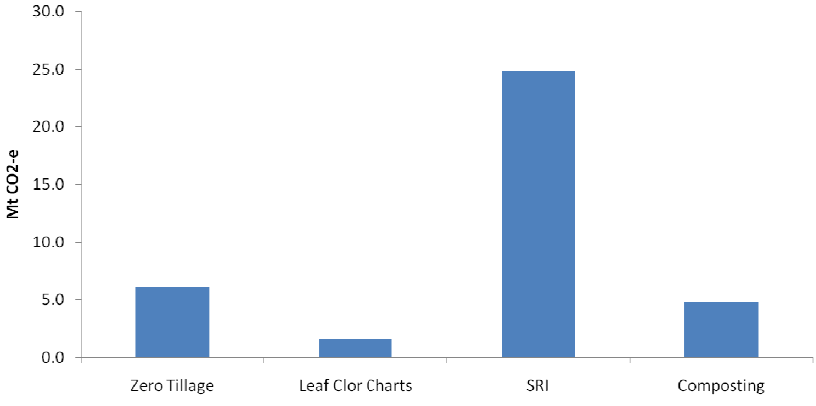

Figure 5 National level cumulative mitigation benefits of mitigation technologies in Indonesia.

Table 3 List of costs and benefits considered for cost benefit analysis of various agro-technologies.[20]

Total costs	Total benefits
Operational costs	Yield per ha (*t*/ha)
Human labor	Value of main product per ha
Bullock labor	Value of by product per ha
Machine labor	
Seed	
Fertilizers and manures	
Fertilizers	
Manure	
Insecticide	
Irrigation	
Interest on working capital	
Fixed cost	
Rental value of owned land	
Land tax	
Depreciation on implements and farm buildings	
Interest on fixed capital	

Sukabumi in the West Java province, Indonesia in 2010.

$$\text{BCR} = \frac{\text{Total Benefits}}{\text{Total Costs}} \tag{2}$$

In terms of BCR, zero-tillage provides higher benefits and lower costs followed by SRI, windrow composting and leaf color charts. It should be noted that there is a mismatch between the outcomes of the marginal abatement cost analysis and cost-benefit analysis. Zero tillage proved to be a lucrative technology for farmers (high benefit cost ratio) while SRI provides to maximum mitigation potential. These calculations may vary once the non-monitory and indirect benefits and costs (negative and positive externalities) are included in the Equation 2. From the

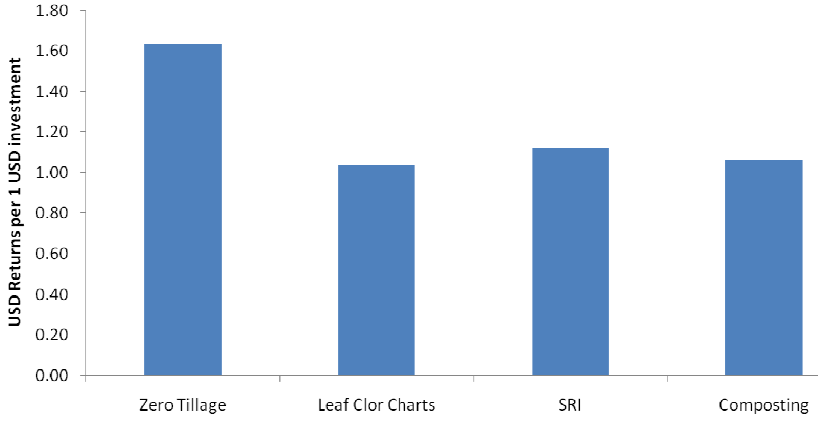

Figure 6 Benefit-cost analysis of various agro technologies in Indonesia.[20]

point of food self-sufficiency, SRI could prove to be a better option at the national level and the same may not work out at the farmer level where costs of these technologies assumes important criteria for technology adoption.

4. Technology Adoption and Need for Support Policies

From the above analysis, it is clear that the assessed technologies provided higher benefit-cost ratio (of more than 1) with significant mitigation potential. Despite these advantages, the current rate of adoption of these technologies is still at nascent stages. To date, the area under zero-tillage is negligible in Indonesia. The area under SRI could be roughly estimated to be <15,000 ha, and substantial amount of paddy straw is still being burnt every year (based on interviews with various stakeholders involved in agriculture policy research in Indonesia. Please refer to the introductory section of this paper). This signifies that there is a huge gap between technologies that are available off the shelf and their adoption rate. This gap could be attributed to several deficiencies at the policy level which are listed below.

- No financial incentives for adopting GHG mitigation technologies (farmers adopt technologies that are profitable).
- The technologies with high abatement potential don't have high benefits per unit investment which farmers consider more (e.g. SRI).

For enhanced technology adoption, there is a need to introduce carbon credits for agriculture sector (soil carbon sequestration) which could provide additional income to farmers. Currently, the carbon price in the EU carbon exchange (ECX) stand at 13 Euros per ton. At this rate, zero-tillage could provide an additional

income of 6 Euros per hectare per season (26 Euros for SRI, 26 Euros for aerobic composting, and 1.7 Euros for leaf color charts). Additional measures could include education and capacity building of farmers through rapid expansion of climate field schools and farmer field schools, a shift from benefit-cost based decision making to marginal abatement cost based decision making (coupled with additional income from the carbon markets), and phasing out agricultural input distorting farm subsidies. Subsidies could be diverted to more carbon-friendly technologies such as soil ameliorants to be applied on peat lands.[21] Improvement of agricultural infrastructure is essential for better performance of some technologies such as SRI. This could include precision leveling of the fields, construction of water delivery and control structures at the tertiary and quarterly canal levels, and better lining and management of primary and secondary canals that enhances the water transmission efficiency with greater adaptation and mitigation co-benefits.

Since agro-technologies are highly location specific, technology targeting in terms of ecological conditions, socio-economic condition of farmers, etc. is important in order to achieve maximum mitigation potential of different agro-technologies. The technology targeting could be done for e.g. by zoning based on irrigated, rain-fed lowland, upland, swampy and tidal swamp and peat ecosystems, and different soil properties.

The most obvious approach for reducing the agriculture pressure on land would be through improving the agriculture productivity. An increase in productivity by 0.5 tons per hectare of rice, wheat, maize, soybeans, sugarcane, cassava, oil palm, and coconut would release an estimated 90 Mha in China, India, Indonesia, Malaysia, Thailand and Vietnam (estimated by authors). This would be more than the land that is lost to deforestation in the last 15 years in South and South East Asia (According to Global Forest Resources Assessment of FAO, South and South East Asia lost 1.3 Mha of forests during 2000–2010).

5. Conclusion

Indonesia has made tremendous progress in productivity gains in agriculture sector in the past decade. However, this progress needs to be sustained if the country needs to gain food and nutritional security which may be undermined by the climate change impacts, if no policy interventions are made to adapt to the climate change impacts. At the same time, Indonesia has announced an economy-wide mitigation target of 20%. Meeting this GHG mitigation target while adapting to climate change is the dual challenge facing the country. Though the country has identified land use and land use changes and forestry as a potential area for GHG mitigation, a substantial amount of GHG emission reduction can also come from agriculture sector as well which has been the area of focus for adaptation in the country. Hence, identifying synergistic agro-technologies could provide win-win opportunity for Indonesia.

In this paper, an effort was made to compare four technologies in terms of marginal abatement costs and benefit cost ratio to prioritize technologies. Results indicate that the system of rice intensification provides maximum gross national GHG mitigation benefits and the zero-till provides the cheapest option of mitigating GHG emissions but falls short in terms of gross national GHG mitigation potential. Keeping in view the food security needs of the country, the system of rice intensification appears to be effective technology if costs involved could be reduced through some incentive mechanism. Introduction of carbon credits in agriculture could provide that incentive. Rapid scaling up of these technologies would have to be achieved through providing sufficient incentives (direct or indirect), capacity building of farmers, enhanced support for rural infrastructure including irrigation facilities for precise irrigation management, and additional investments in the research and development. There have already been efforts to enlist various GHG mitigation technologies within agriculture sector in Indonesia, several of which are already available either in a ready-to-adopt or at the early stages of adoption. The next stage is to prioritize and promote these technologies at the farmers' level through providing enabling environment.

Acknowledgements

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A Decision Support System to Deal with Contemporary Issues of Climate Change Induced Vulnerability and Human Security in Malaysia

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Environmental displacement has become a contemporary global concern due to the increasing intensity of climate change effects on peoples around the world. In recent times, this issue has become a socio-political problem due to the increasing rate of displacement within and outside of a country. Therefore, environmental security has emerged as a new concept and growing issue within the domain of human security. This development has become a political issue, due to socio-economic and cross border involvement as well as problems that have emerged within countries. Also, remarkably little attention has been given to analyze, monitor, evaluate and predict changes that are involved in the causes and consequences of climate change induced vulnerability and human security. Similarly, detailed studies on the causes due to such contemporary issues are lacking, globally. For this paper, it is intends to identify causes, consequences and projections of environmental degradation, and the vulnerability of human livelihood caused by climatic and hydro-meteorological disasters in Malaysia. Therefore, this paper discusses issues to do with flood-related vulnerability both in rural and urban areas, and its impact on human security in Malaysia. It also outlines the potential scientific tools that may be applied to predict, evaluate and plan to overcome the problem. The prime objective is to identify and to develop a new paradigm integrating tools of socio-economic, cultural and scientific aspects. It is assuming that, this effort would be able to put forward a theme to integrate scientists, social scientists and policy makers to work together to solve such issues.

Keywords: Decision Support System (DSS), Environmental displacement, Flood hazard, Flood governance, Geographical Information System (GIS), Human security, Vulnerability.

1. Introduction

Vulnerability to climate change induced disasters is a foremost concern in the national and international agenda because the affected peoples face threats from different sources or entities. In particular, environmental displacement as a

contemporary problem has become a threat which is increasing day by day. As a matter of fact, the problem of environmental refugees has attracted global attention, as is the case of Lester Brown of the WorldWatch Institute who defined such these migrants as 'environmental refugees' in the 1970s.[27] Later, this term has become popular following Essam El-Hinnawi's treatise on the topic for the United Nations Development Programme (UNDP) in 1985.[9,14] In 1990, the First Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) warned that the gravest effect of climate change would be resulted to human migration.[11] More recently, Norman Myers has defined environmental refugees as "people who can no longer gain a secure livelihood in their homelands because of drought, soil erosion, desertification, deforestation and other environmental problems, together with associated problems of population pressures and profound poverty."[21] Consequently, the human impact on the environment is exposing a new frightening reality for the globe that the increasing number of people displaced as a result of climate change.[20,32] It also indicates that, this potential catastrophe will surpass all known refugee crisis in terms of the number of people affected.[1,2] Thus, environmental migration or displacement appears a rapidly emerging catastrophe for the international community.[31]

The United Nations High Commission for Refugee (UNHCR),[29] defined refugees as, "*any person who owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, is outside the country of his nationality and is unable or, owing to such fear, unwilling to avail himself of the protection of that country; or who, not having a nationality and being outside the country of his former habitual residence as a result of such events, is unable or, owing to such fear, is unwilling to return to it*". Although, this definition is a rather well-accepted definition, it omits the phenomenon of environmental migrants or refugees, such as those affected by floods, tsunamis and earthquakes.

In fact, this terminology became common usage after a 1985 United Nations Environmental Programme (UNEP) policy paper entitled 'Environmental Refugees'.[4,9] The International Association for the Study of Forced Migration (IASFM) defined environmental migration as "*a general term that refers to the movements of refugees and internally displaced people (those displaced by conflicts) as well as people displaced by natural or environmental disasters, chemical or nuclear disasters, famine, or development projects*."[30] Climate change or environmental disaster induced migrants are also classified as environmental migrant, climate change-induced migrant, ecological or environmental refugees, climate change migrants and environmentally-induced forced migrants.

In order to develop a sustainable solution of above mentioned issues, some vital questions are pertinent to recognize: a) what are the types and causes of environmental induced displacement? b) how to measure the vulnerability of affected people that arise due to the environmental displacement? c) how to develop a comprehensive decision support system to save such vulnerable population? Answering to these questions are crucial in order to save vulnerable population

from the problems they have been suffering from and to provide a fruitful disaster management solution.

Keeping these issues in mind, the focal objectives of this article are, a) to identify the facts and trends of rural and urban floods, b) to discuss the suitable method to measure vulnerability caused due to environmental disasters, c) to outline a methodological framework in order to develop a comprehensive decision support system approach whereby historical, socio-economic and scientific aspects will be integrated. In such circumstances, floods and hydro-meteorological aspects are given preference to ascertain a possible framework to safeguard human security. This article reviews the literatures available in topics, and we integrate those in order to make a bridge within the themes for a sustainable solution of the issues. Furthermore, this is a preliminary effort to develop a decision supporting tools of an integrated system. It is assumed that, if a well accepted framework can be developed considering the environmental disasters, this approach would be able to provide a decision support system to safeguard human wealth and national security.

2. Types and Causes of Floods in Malaysia

Malaysia is locating in the Southeast Asian tropical region which is characterized with heavy rain round the year.[28] Topography of Malaysia is rough, mostly covered by hills and mountains. The central mountain range is hosting the dense forest range known as "Banjaran Titiwangsa" (central forest spine), hosting diverse flora and fauna. However, rapid development activities, for example, transportation networks, urban sprawl, Industrial settlements, housing estates, agriculture are making many of these forested hills uncovered. As a result, slope failure, poor drainage and siltation are increasing day by day and causing many disasters like landslides, urban floods and flash floods in the downstream. Considering these reasons, climatic and hydro-meteorological disasters in Malaysian context were selected as a case to study.

The most severe hydro-meteorological natural disasters in Malaysia are monsoon floods and flash floods.[23,28] These floods are common hydrological phenomena in Malaysia,[28] on average affecting an area of 29,000 km^2. More than 4.82 million people (22% of the population) and inflicting annual damage of USD 305 million.[5] There are essentially two reasons why floods occur in Malaysia. First is natural causes, which are short but with high intensity, can lead to flash flooding, as well as heavy widespread rain that can lead to land inundation. Second are human induced floods due to the disposal of solid wastes into rivers, sediments from land clearance and construction areas, an increase in impervious areas and the obstruction and constriction in the rivers. Both apply to urban and rural areas in Malaysia.

Flooding of areas used for socio-economic activities produces a variety of negative impacts.[3] The magnitude of adverse impacts depends on the

vulnerability of the activities and population and the frequency, intensity and extent of flooding. World Meteorological Organization (WMO) documented some negative socio-economic impacts on human livelihood (http://www.apfm.info/helpdesk/q_and_a/social_05.htm, accessed on 20 January 2013) are shown below:

i. Loss of lives and property: Immediate impacts of flooding include loss of human life, damage to property, destruction of crops, loss of livestock, non-functioning of infrastructure facilities and deterioration of health condition owing to waterborne diseases. Flash floods, with little or no warning time, cause more deaths than slow-rising riverine floods.
ii. Loss of livelihoods: As communication links and infrastructure such as power plants, roads and bridges are damaged and disrupted, economic activities come to a standstill, resulting in dislocation and dysfunction of normal life for a period much beyond the duration of the flooding. Similarly, the direct effect on production assets, be it in agriculture or industry, can inhibit regularly activity and lead to loss of livelihoods.[17] The spillover effects of the loss of livelihoods can be felt in business and commercial activities even in adjacent non-flooded areas.
iii. Decreased purchasing and production power: Damage to infrastructure also causes long-term impacts, such as disruptions to clean water and electricity, transport, communication, education and health care. Loss of livelihoods, reduction in purchasing power and loss of land value in the flood plains lead to increased vulnerabilities of communities living in the area. The additional cost of rehabilitation, relocation of people and removal of property from flood-affected areas can divert the capital required for maintaining production.
iv. Mass migration: Frequent flooding, resulting in loss of livelihoods, production and other prolonged economic impacts and types of suffering can trigger mass migration or population displacement. Migration to developed urban areas contributes to the overcrowding in the cities. These migrants swell the ranks of the urban poor and end up living in marginal lands in cities that are prone to floods or other risks. Selective out-migration of the workforce sometimes creates complex social problems.
v. Psychosocial effects: The immense psycho-social effects on flood victims and their families can traumatize them for long periods of time. The loss of loved ones can generate deep impacts, especially on children. Displacement from one's home, loss of property and livelihoods and disruption to business and social affairs can cause continuing stress. The stress of overcoming these losses can be overwhelming and produce lasting psychological impacts.
vi. Hindering economic growth and development: The high cost of relief and recovery may adversely impact investment in infrastructure and other development activities in the area and certain cases may cripple the frail economy of the region. Recurrent flooding in a region may discourage long-term

investments by the government and private sector alike. Lack of livelihoods, combined with migration of skilled labor and inflation may have a negative impact on a region's economic growth. Loss of resources can lead to high costs of goods and services, delaying its development programs.

vii. Political implications: Ineffective response to relief operations during significant flood events may lead to public discontent or loss of trust in the authorities or the state and national governments. Lack of development in flood-prone areas may cause social inequity and even social unrest posing a threat to peace and stability in the region.

Agriculture in Malaysia contributes to about 3.9% of the GNP and at least a third of the country's population depends on the agricultural sector for their livelihood.[8] Thus, significant climate change, including flood disasters affect the agricultural sector in terms of production. Most recently though, flooding has become a serious urban problem with severe socio-economic problems affecting both the rural and urban population. In agriculture, one of the factors that have continuously affected the sector is flooding.[12,13] Flooding can be defined as any area of land covered by water which is normally dry. Sometimes water levels can rise slowly and without giving prior notice. Other times, floods can be rapid, sudden and unexpected. Malaysia has been facing both types of flooding with high socio-economic affects.[23] Without adequate measures, the occurrence of floods could cause the displacement of large numbers of people, damaged infrastructure and losses of agricultural production from eroded/inundated lands. In general, about 9% of the land area in Malaysia (2.97 million ha) is flood prone and as many as 3.5 million people have become victims. Monetarily, it is difficult to estimate the quantum, but a conservative figure of US$ 35 million has been used to estimate the average flood damage per year. This figure includes both urban and rural sectors.

The types of socio-economic impacts are as follows:

i. Loss of agricultural production from eroded/inundated lands;
ii. The displacement and relocation of flood victims with associated disruption of business and economic activities;
iii. The loss of fisheries production due to mangrove loss; and
iv. Interruption of port operations.

In the year 2000, statistics of socio-economic impacts of flooding were based on the high rate of sea level rise.[19] There was a loss of US$ 15 million for the Western Johor Agricultural Development Project area, which accounts for about 25% of the national drainage area. Long-term annual flood damage was estimated at about US$ 30 million for Peninsular Malaysia and US$ 4 million for Sabah/Sarawak based on the 1980 price level. If the flood frequency is doubled, the annual flood damage will increase by 1.67 times. There was a US$ 100 million loss based on 20% loss of mangrove resulting in a decrease of about 70,000 tons of prawn production valued at US$ 1,500 per ton.[6] Recent urbanization amplified the cost of damage in

infrastructure, bridges, roads, agriculture and private commercial and residential properties. During the recent Johor 2006–07 floods due to a couple of "abnormally" heavy rainfall events which caused massive floods, the estimated total cost of these flood disasters was US$ 0.5 billion, considered as the most costly flood events in Malaysian history.[15] At the peak of this flood, around 110,000 people were evacuated and sheltered in relief centers. The death toll was 18 persons.

3. Scenario of Human Displacement and Associated Loss Due to Hydro-Meteorological Disasters in Malaysia

Since 1920, Malaysia has experienced several crucial floods and the intensity and frequency have been increased over the past two decades.[28] Some of the remarkable flood occurrences were in the years of 1926, 1963, 1965, 1967, 1969, 1971, 1973, 1979, 1983, 1988, 1993, 1998, 2005, 2006, 2011. It revealed that the occurrence of floods has become yearly events since 1963. These floods caused a common disaster for the inhabitants of both rural and urban settings. Floods that occurred in December 2006 and January 2007 in the State of Johor, a southern state of peninsular Malaysia, was particularly a devastating one. Historically, the January 1971 flood that hit Kuala Lumpur and many other states had resulted in a loss of more than US$ 70 million and the death toll was 61 persons. However, during the recent Johor 2006–07 floods due to heavy rainfall caused massive floods and the estimated total loss in terms of monitory value was US$ 0.5 billion. This was considered as the most expensive flood in Malaysian history. The recent Johor flood displaced around 110,000 people who had to be sheltered in relief centers. A number of people also migrated to the urban area to avoid sufferings in future. The death toll was 18 persons. These environmental refugees were mainly agriculturalists who had to abandon their crops and villages to find refuge in urban centers. Although, after a temporary migration, many of the affected communities had returned to their previous land, but many of them decided to migrate permanently to a safer environment preferably in the urban areas. In recent time, urbanization amplified the flood caused the cost of damage in infrastructure such as bridges, roads, and private commercial and residential properties. Figure 1 illustrated drastic effects of these hydro-meteorological disasters on human life, infrastructures and wealth.

Presently, about 60% of the Malaysian population now resides in urban areas, and the density of the population is increasing day by day. In Selangor, where the federal territory of Kuala Lumpur is situated in the centre, the built up area increased from 4% to the 20% between the years 1988 and 2005.[24] This scenario is increasing exponentially. Consequently, many of other problems such as healthy sanitation and an efficient drainage tremendously challenged. As a result, flash flooding in urban areas are perceived to be the most critical flood type (surpassing the monsoon flood) since the mid 1990's. This is reflected in

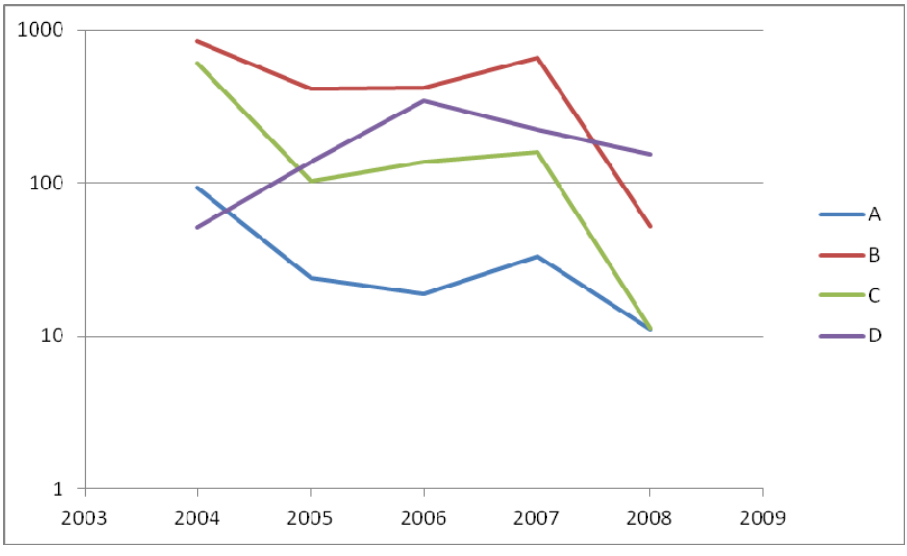

Figure 1 Drastic effects of extreme events on human due to recent hydro-meteorological disasters in malaysia. A = death tolls; B = injured; C = total affected people (in thousand); damage costs (in USD). (*Source :* ADRC Country Report 2008 and 2006, Retrieved from www.adrc.asia.com on 23 December, 2012).

the flood frequency and magnitude, social-economic disruption, public outcry, media coverage and the government's escalating allocation of funds to mitigate them.

4. Vulnerability and Decision Support System (DSS)

The term 'vulnerability' has been used in many different ways by various scholarly communities. The scientific use of 'vulnerability' has its roots in geography and natural hazard research. However, this term has been used in a variety of disciplines such as ecology, environmental health, sustainable development, human security, land use change, and climate impacts and adaptation.[10] Vulnerability have a keen relation with the social system that includes the threat, the region, the sector, the population group, the consequence, and the time.[7] Metzger *et al*.[18] specifies the vulnerability of ecosystems to global change with respect to the ecosystem service, a location, a scenario of stressors, and a time scale. Thereby, environmental displacement has become an another dimension of vulnerability. Because while human livelihood exposed to the environmental hazards such as, flood, tsunami, or landslide, they have to tackle the situation by the cost of their physical, mental or financial wealth. This phenomenon thus related with the human security and a comprehensive management system may save human livelihood through reducing exposure to the hazards.[26] Besides, vulnerability of

social beings may reduce through proper management of disaster risk and climate change induced problems. Therefore, an initiative to develop a methodological framework for integrated management system is crucial in the country to regional scale. Particularly it is indispensable in the South and Southeast Asia where the related stakeholders are lacking appropriate understanding, required capacity and policy initiatives.[17,26]

4.1. *How to Measure Vulnerability*

As vulnerability related to the human and their settlements in space and time, they are measureable.[22] A multi-criteria decision support system may be helpful in measuring and mapping hazard and vulnerability of a particular environmental problem. It is necessary to identify the risk zones which will help national policy decisions to save human life and to avoid induced migration. Geographical Information System (GIS) has such facility to integrate different types of information as different layers into its platform.[16] Using intellectual properties of analytical hierarchy processes (AHP) it produces decision supporting output that based on the preferences of a number of criteria or sub-criteria of an emerging problem.[16] Aforementioned aspects may be the criteria of such measurement where a number of sub-criteria can be incorporated. Generally, vulnerability has three principal dimensions e.g., the economic, the social and the ecological.

The economic dimension of vulnerability naturally deals with economic damage potential of a said region. This dimension represents the risk of resource production, distribution and consumption. This vulnerability mount at a high degree in the developed area because of the costly damage take place in the infrastructure and communication system.

The social dimension of vulnerability of a population is related to the human distribution, education, culture and earning capacity of that region. Commonly, poor population groups are considered to be most vulnerable. They use to suffer in every sector of a disaster or event, such as an early warning, preparedness of disaster, during disaster, and after a disaster.

To measure the vulnerability, it is crucial to define social context of human population in a region. The disaster risk reduction (DRR) system must consider this issue for the sake of the human security. Therefore, an integrated scientific and sociological management system may be a useful approach for reducing vulnerability of a population.

4.2. *Use of Modern Technology*

In this context, by using geographical information system (GIS) as a tool to integrate different sources of information for a proper decision support system (DSS) can be a useful solution.[16,18] A GIS classifies a set of given criteria according to their assigned weight imposes for their importance for a particular reason

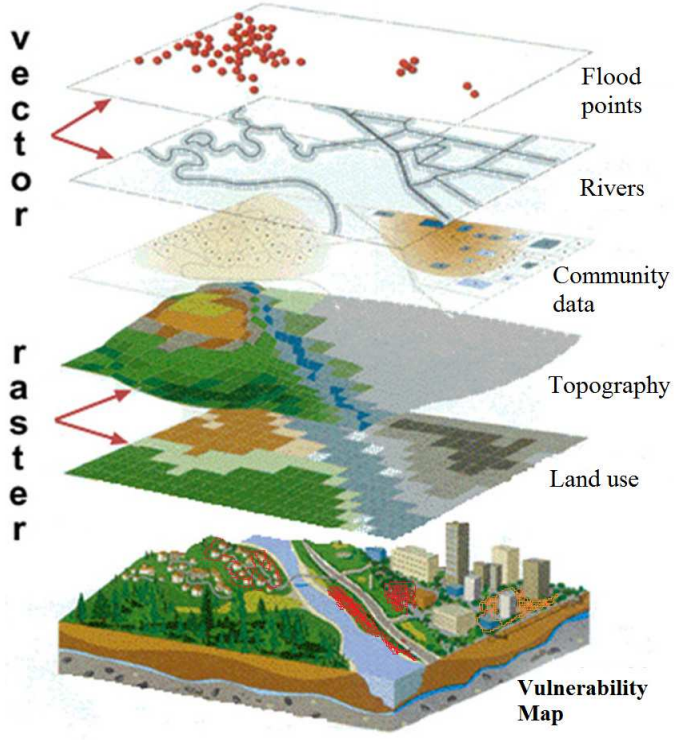

Figure 2 Different layers of information to develop a multi-criteria vulnerability map for flood hazard.

e.g., flood risk. Figure 2 shows how a number of criteria can be layered in a GIS and how they give an output from these input information. Through this, a number of decision supporting index, maps and graph can be available. Some of those are a hazard map, a vulnerability map, and a risk map. This will help to identify most vulnerable community in a region due to a particular hazard, for example, Flood. A number of assessment may be applied for cross experimentation. After a recurrent evaluation, a vulnerable community and zone can be identified. Later, local authority or government can take proper initiative to relocate or take necessary measures to reduce the risk of that affected community.

5. Conclusion

In recent years, rapid urban development within river catchment areas have resulted in higher runoff and deteriorated river capacities. This has in turn resulted in an increased flood frequency and magnitude.[28] The consequences and factors affecting these events have been identified in this article. Moreover, a possible way to identify the vulnerable community and the future projection of vulnerability

can be delineate through this methodology.[16,18,22] It is also may need to develop the approach further. It is beneficial to integrate community related information in the scientific measurement. Because, mass people are affected and they have the capability to act faster for disaster management.[24]

As 60% of the Malaysian population now residing in urban areas, flash flooding in urban areas are perceived to be the most critical (surpassing the monsoon flood) since the mid 1990's. This is reflected in the flood frequency and magnitude and has led to socio-economic disruption, public outcry, increasing media coverage and the government's need to escalate allocation to mitigate them.[23] How, then, can we overcome the socio-economic impacts of floods and preserve human security in Malaysia? Both the government and private sectors have to be involved to mitigate this disaster.[25] Human security must be preserved if Malaysia is to continue to progress to become a developed country in years to come.

To reduce flooding, flood cause problems like migration and preserve human security, Malaysia has to adopt a multi-pronged approach which involves all sectors of society. In such circumstances, to reduce flood related problems e.g., migration, human security, a multi-criteria flood risk mapping is crucial. An integrated framework is beneficial to reduce flood risk and associated natural and social imbalances.[18] This article emphasized on this issue and describes a possible way to measure vulnerability using modern geospatial technology. This is, in fact, a step forward to develop a comprehensive approach. Despite, much debate is going on that how different issues can be contextualized within the same approach while generally they are described at a fairly considerable distance. However, we tried to integrate those aspects using Geographical Information Science (GIS) platform. In fact, GIS has that capability to incorporate different information in terms of points, lines and polygons in its domain.[16,22] Therefore, number of aspects related to the socio-economic and demographic aspects of the community can be weight with the events of environmental aspects like climatic and hydro-meteorological occurrences, frequencies, intensities.

Here, we documented a possible way to solve these issues in order to develop a decision support system for sustainable management. This is not enough, but more crucial tasks will be to incorporate scientists, social-scientists and policy makers in this holistic effort. Academic institutions have the opportunity, and they must take the responsibility to move this integrated effort forward to the final stage where community will be benefitted.[24] At the same time, political will is also noteworthy because they will implement this in the society. Local stakeholders must involve in the mitigation programs. In addition, a regional treaty and networking is terribly essential to solve the problem holistically. Topics such as anti-littering campaigns, degradation of the forests and responsible and sustainable development procedures should be integrated into the education system. Most of all, to prevent the regular occurrence of floods and flood associated problems, the mass media should take on more responsibility to spread the causes and solutions to this problem.

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Climate Change Adaptation and Freshwater Resource in Malaysia: Creating a Culture of Intellectualism

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This paper is a discussion of the influence of the culture of intellectualism on conceptions of, and behavior towards climate change adaptation in Malaysia. We illustrate how certain conceptions of the relation of human beings to the natural environment, mainly freshwater resources, may lead to policy formulation, which in turn, if implemented wisely, will ensure freedom from problems relating to either the damaging excesses or scarcity of freshwater resources. We also discuss the role of the culture of intellectualism as a generator of useful coping strategies, in the context of environmental depletion, particularly relating to freshwater resources.

Keywords: Climate change adaptation, Freshwater resources, Cultural intellectualism.

1. Introduction

Malaysia ranked 52 in the 2009 Climate Change Performance Index, an instrument that evaluates and compares the climate protection performances of the 57 countries that are responsible for more than 90 percent of global energy-related CO2 emissions. In 2011, Malaysia ranks 53 (Climate Change Performance Index [CCPI] 2011). As we can see, the trend is upwards. This is why Malaysia now has a National Policy on Climate Change (NPCC) in Malaysia. There are 5 reasons for having the NPCC: 1. Climate change is cross-sectoral in nature; it affects the environment, economic growth and human well-being, or human security. 2. Climate change adaptation and mitigation measures need to be mainstreamed into national development plans; 3. Any changes in climate over time will directly and indirectly affect human activities as well as natural systems and processes, such as the quantity and quality of rainfall, air quality, biodiversity and ocean levels; 4. The impacts of climate change will undermine development, affect human security and threaten the security of natural resources; 5. Strategic responses are necessary to strengthen Malaysia's resilience to the impacts of

climate change. Malaysia's NPCC was tabled in 2010 by the Ministry of Natural Resources and Environment, Malaysia (NRE, 2010). It is a blueprint which provides the framework to mobilize and guide government agencies, industry, community as well as other stakeholders (i.e. entrepreneurs, farmers, NGOs, educational institutions, fishermen, conservationists, tourists and the general public) and major groups in addressing the challenges of climate change in a holistic manner. The policy statement is as follows: to ensure climate-resilient development to fulfill national aspirations for sustainability. The objectives of the NPCC, Malaysia are to:

- Mainstream climate change through wise management of resources and enhance environmental conservation resulting in strengthened economic competitiveness and an improved quality of life;
- Integrate responses into national policies, plans and programs to strengthen the resilience of development from the potential impacts of climate change; and
- Strengthen the institutional and implementation capacities of all stakeholders to better harness opportunities in order to reduce the negative impacts of climate change.

Malaysia recognizes the adverse effects of climate change and has outlined the following three objectives:

- To strengthen the implementation of climate change actions that contribute to environmental conservation and sustainable use of natural resources such as freshwater; and
- To coordinate and incorporate the implementation of climate change considerations into development programs at all levels.
- To instill effective participation of stakeholders and major groups in order to effectively implement successful mitigation and adaptive policies to overcome the negative impacts of climate change.

The policy suggests key actions to be taken by all stakeholders. The first key action is to conduct systematic reviews and harmonize existing legislation, policies and plans, taking into account and proposing relevant balanced adaptation and mitigation measures, to address agriculture and food security; natural resources and environment (water, biodiversity, forestry, minerals, soil, coastal and marine and air); energy security; industries; public health; tourism; transportation; infrastructure; land use and land use change (including land reclamation); human settlements and livelihood; waste management; and disaster risk reduction. The second key action is to incorporate climate change as a priority area in the National Development Planning Council. The third key action is to establish an interministerial and cross-sectoral committee to enable the implementation of climate change measures.

The NPCC has tabled 5 principles and 10 strategic thrusts or planning and implementation programs. Under principle number 2 (P2), 'Conservation of

Environment and Natural Resources', the underpinning suggestion incorporates all natural resources, including freshwater (NPCC, 2010: 5–7). However, problems associated with freshwater resources and its effects on the environment are not tabled in detail.

This paper has three objectives. First, to mobilize and guide government agencies, industry, community as well as other stakeholders and major groups in addressing the challenges of climate change in a holistic manner in relation to the management of the environment; Second, to instill a positive development ethic by applying the culture of the intellectual in the governance processes in implementing adaptation and mitigation; and third, to note that the intellectual culture of all stakeholders may serve as a 'tool' so that we can conclude that a deeper understanding of the behavioral responses to climate change may be of significant value in the long-term development of resilience against accelerating climate change in general, and the availability of freshwater resources in particular.

2. The Role of the Culture of the Intellectual: Climate Change Adaptation and Freshwater Resources

The objectives discussed above can be achieved if we look at the important role that intellectual culture can play in climate change adaptation and the sustainable use of natural resources. For the purpose of this paper, we use the term 'culture' in a specific manner, i.e. the culture of the intellectual approach to problem-solving. An intellectual is a person who is engaged in thinking about ideas and problems using the faculty of reason (Alatas, 1977: 8). In the case of climate change adaptation, children must be exposed to an intellectual atmosphere or attitude of mind conducive to creative development. Therefore, the notion of climate change adaptation and mitigation should be instilled in the minds of the younger generation in the form knowledge of climate change and its associated negatives. This can be done in the home, kindergarten, primary and secondary schools as well as at tertiary education levels. However, this means both parents and teachers/lecturers themselves have to be aware of the fundamental problems tackled by climate change science and social science, and the synergy between humans and the environment. An important step is to cultivate the spirit of the enquiring mind, to develop a culture of intellectuals who can explain the problems of the society-environment nexus and can attempt to find solutions, either before or after disaster has struck. We should never discount the fact that the intellectual is equally responsible to produce ideas and spread them to other members of society. The NPCC is a blueprint through which intellectual culture can play a role, in advising problem-solvers and implementing agencies (government and private sector) to look at the longer-term effects. For example, the disappearance of forests in Malaysia has generated a slew of related problems, from displacement of forest-dwellers, the destruction of marine life, a loss of bio-diversity, water pollution and

a decline in economic performance. In order to prevent, adapt to and mitigate these disasters, intellectuals must manifest the following social characteristics:

- They are recruited from all classes;
- They are to be found supporting or opposing various cultural or political movements;
- Their occupations are usually writers, lecturers, poets, journalists and sometimes, politicians and other state decision-makers;
- They are not merely interested in the purely technical and mechanistic side of knowledge; they are interested in ideas about religion, culture, the good life, art, nationalism and the planned economy; and
- They look at problems on a longer trajectory of time sequence (long-term effects).

It is the fourth point that most concerns us. Without discounting the vast scientific contribution to the study of climate change and its effects on human, animals and other forms of organic life, what is lacking in developing countries like Malaysia is the important role of the intellectual. In Malaysia, for instance, the culture of intellectualism should be applied to the disasters such as the freshwater crisis. Intellectuals must relate their thoughts to the wider context of life and thought, penetrating into fundamental values and commitments in preventing, adapting and mitigating problems of freshwater scarcity. For example, scientists have done a lot of research on how far Malaysia's rivers have been polluted. Intellectuals, on the other hand have not done enough to educate the public and influence the implementation of policies that the public will follow. There is no use having a 'Love Our Rivers' (*Cintai Sungei Kita*) campaign (1993) lasting a weekend, a month or even a year without the intellectual stepping in to provide leadership in the ideas of *how* the rivers became polluted, *why* they remain polluted, and *how* to overcome societal behavior with respect to keeping a clean river. (Ministry of Natural Resources and Environment [NRE], 2007; Department of Irrigation and Drainage, 1993). Many years have passed since the campaign, and the outcome has been negligible. Table 1 below illustrates this.

Table 1 Status and trends of river water quality, Malaysia 1988–1994.

	Status in 1994			Overall rate of change	
Pollutants	Polluted	Slightly	Clean	(1988–1994)	
Biological Oxy. Oxy. Demand (BOD)	13 13%	18 (15%)	83 (72%)	−0.88	Deteriorated
Suspended Solids (SS)	66 (57%)	16 (14%)	34 (39%)	−0.91	Deteriorated
Ammonia cal Nitrogen (NH_3-N)	36 (31%)	35 (30%)	45 (39%)	−1.72	Deteriorated
Overall Water Quality Index (WQI)	14 (12%)	64 (55%)	38 (33%)	−0.92	Deteriorated

Source: UNEP/SCS-National Report Malaysia.

From the table, suspended solids and ammoniacal nitrogen were the main pollutants accounting for 57% and 36% of the total polluted rivers respectively. The Drainage and Irrigation Department had initiated another program in 2002 to clean up the Klang River, i.e. to clean the river of solid waste and silt, to improve water quality to Class III (recreational purposes without body contact) and to beautify strategic stretches of the river for recreational purposes (Chan, 2002). So far, it has had mixed results. Some stretches in the cities are showing good results as more attention has been focused there but elsewhere the river is as dirty as ever (Chan, 2002). Malaysian rivers are still polluted, and people seem to have forgotten about the campaigns. It is the duty of the intellectual to constantly remind society of the dangers of bad practices that pollute Malaysia's freshwater resources as well as to keep the executive branch of government 'on their toes' in terms of being consistently dedicated to finding the sources of freshwater pollution. The adage 'prevention is better than cure' is apt. The function of intellectual culture must be relentless.

With respect to freshwater in Malaysia, we have only a negligible functioning group of dedicated intellectuals whose duty is to bring up a level of consciousness and insight into vital problems on environmental plunder in general, and freshwater scarcity, in particular. The most conspicuous reason is the absence of the intellectual spirit or the philosophic spirit. (Afghani, 1886). The spirit of inquiry, the sense of the enchantment of intellectual pursuit and the reverence for scientific and rational knowledge are not widespread in the developing societies like Malaysia (Alatas, 1977: 11).

The freshwater problem in Malaysia is acute. The Klang River, for instance, the largest and main river of the Klang Valley, flows through Kuala Lumpur and Selangor (i.e. the Klang Valley), and eventually into the Straits of Malacca. Much of Klang River's pollution is due to untreated sewage, untreated industrial waste, wrong connection of pipes and soil erosion. Sewage goes straight into the river due to inadequate water piping not being linked to the sewage connection pipes. The Selangor State employed the services of a company, Wessex Water to help 'clean up' the Klang River. It's managing director Gareth Jones said that "The status of the Klang River now lies between critical and bad. There is a lot of trash that needs to be weeded out but the river can be saved and improved" (Ng, 2010). There seems to be no joint effort by local authorities and communities to check on this. This is because there is no culture of shame among stakeholders. The culture of shame would ensure that humans and their surroundings be kept neat and clean. Another problem is the lack of water sustainability in water courses and catchment areas. The natural environment of the coastal areas of Klang are under threat from many sources, including pollution from land and sea-based activities, indiscriminate and improperly planned coastal development, over fishing and destruction of natural habitats.

Table 2 illustrates the acute pollution facing Malaysia's water. The quality of coastal waters of the Klang and Langat Rivers, for instance, is declining due to

Table 2 Malaysia: Total biochemical oxygen demand (BOD) load (kg/day) from sewage treatment plants.

State	No. of STP	Total PE	Flow (m^3/day)	BOD load (kg/day)
Selangor	2,563	5,908,450	1,329,401	332,350.31
Perak	1,343	1,300,430	292,597	73,149.19
Johor	1,010	1,198,417	269,644	67,410.96
Negeri Sembilan	928	931,458	209,578	52,394.51
Kedah	755	556,637	125,243	31,310.83
Melaka	725	570,192	128,293	32,073.30
Pulau Pinang	650	2,149,001	483,525	120,881.31
Pahang	486	314,830	70,837	17,709.19
WP Kuala Lumpur	299	2,571,877	578,672	144,668.08
Terengganu	224	75,184	16,916	4,229.10
Perlis	36	16,156	3,635	908.78
WP Labuan	32	39,265	8,835	2,208.66
WP Putrajaya	9	72,833	16,387	4,096.86
Total	**9,060**	**15,704,730**	**3,533,563**	**883,391.08**

Source: Indah Water Konsortium Sdn. Bhd.

the increased dumping of waste into upstream catchment areas, especially from housing and industrial areas, as well as discharges from agricultural and urban areas. (The Star Online, 2003). The coastal areas of Klang bear the full force of all impacts from activities and development carried out in the upstream catchment areas of the Klang River. The latter, plus the two major tributaries, namely *Sungai* Selangor and *Sungai* Langat are seriously polluted by sewage discharge, industrial wastewater and land runoff (leaving the river inundated with silt), which are not properly treated. The river and coastal waters are contaminated by Escherichia Coli (*E. Coli*) in excess of the marine water quality standards (Ali & Budari, April, 2011). Other contaminants, such as inorganic chemicals, are also present, which will not only threaten the ecosystem, but also enter the food chain resulting in human health risks.

Port Klang is the premier port of Malaysia, with more than 14,207 vessel arrivals. The port does not have reception facilities for wastes from ships which exposes the port and Klang Valley in general to potential threats of oil spills from port operations. In additional to this, waste discharges from ships in transit through the Straits of Melaka, or shipping accidents in the port or in the Straits, are a constant threat to the coastal waters and resources of the area (Wolanski, 2006). Below is a range of issues and threats to the integrity of the Klang Valley.

3. Issues and Threats

According to the Department of Environment, the main sources of water pollution are from livestock farms, domestic sewage, land clearings and a small percentage from agro-based and manufacturing industries. Oil and grease, suspended solids

and *E. coli* are the main pollutants in the coastal waters. Pollution caused by solid waste mismanagement is a very serious environmental problem. Industrial, commercial and domestic activities produce solid waste, which enters coastal waters through the drainage systems and rivers.

Excessive erosion and sedimentation occur due to uncontrolled development activities along the coast and upstream water catchments areas. Natural habitats provide important functions, such as sanctuaries and nurseries for fish, shellfish, and other marine habitats. Usage of illegal fishing gear and encroaching into other fishing areas contravene the conditions of fishing licenses. Illegal logging in mangrove forests, cutting of forests in upstream coastal and hinterland areas for housing, agriculture and other activities.

On average a Malaysian uses 300 liters of water a day, double the recommendation by United Nations of 150 liters/day. In the most densely populated states, the river basins have reached their limit to maximize supply. Contaminated water supplies (e.g., for drinking and cooking) and contaminated seafood pose risks to human health, and results in increased infrastructure and health care costs.

The breeding, growth and quality of fish/shellfish are adversely affected by water pollution. The deterioration of the quality of the coastal waters of the Klang and Langat Rivers make these areas unsuitable for recreational purposes, such as swimming and diving, resulting in a decline in tourism. Pollution adversely affects fishermen, indigenous communities and individuals who depend on these areas as sources of livelihood, which directly affects the economic resources of the country.

Solid waste is capable of destroying the ecosystem, smothering the habitats, ruining the aesthetic value of coastal vistas and resulting in risks to human health. Solid waste also obstructs the flow of water in storm water drains and rivers, causing floods. Mismanagement of solid waste results in social, economic and environmental losses to the community.

Disruption of the process of photosynthesis and alteration of the benthic communities affect the natural life cycle in the ecosystem. Shallowing of coastal waters affect navigation and access to ports. Obstruction of natural flow and drainage, hence causing floods. Changes in depth and positions of coastlines as well as accumulation of sediment into navigational routes of the port, resulting in increased dredging costs to deepen access routes. The costs to build and maintain beach stabilization/protection walls and other coastal structures are increased.

The destruction of mangrove forests and peat swamps, due to clearing of land for agriculture, logging and other development works, will result in losses of ecological functions such as breeding grounds and nurseries for a variety of marine life as well as a natural defense against coastal erosion. The stocks of flora and fauna are dwindling and biological diversity is threatened. Dwindling resources adversely affect the livelihood of individuals who depend on the natural resources, resulting in increased poverty. The functions of forests as natural erosion buffers, water catchments areas and river banks are lost.

4. How Cultural Intellectualism can Contribute

Cultural intellectualism has a huge task on its hands, to change the mindset of Malaysian society when it comes to conservation, adaptation and mitigation. Our concern for the emergence of a functioning intellectual group should be considered as a development need. To date, all the 5-year Malaysian Development Plans has not focused on this inconspicuous but vital component of society. They (the intellectuals) are a vital condition for nation building as well as preservation of the nation from all facets of threats, including environmental threats. When referring to the freshwater/river problem in Malaysia, we are faced with an abundance of non-intellectuals. The latter can be described as follows:

- Though educated, he/she is passive mentally;
- He/She accepts what is taught uncritically;
- He/She does not exert himself thinking about problems over a span of years;
- He/She is not emotionally committed to the intellectual pursuit;
- He/She does not long for an intellectual discussion because he/she feels no need for it;
- He/She does not spend time reading on serious subjects;
- He/She is not capable of forming an opinion beyond what is obvious;
- If he/she is a specialist, his/her knowledge of subjects outside his/her field is comparable to that of a layman; and
- He/She has no will to think and lacks the ability to see consequences into the future, i.e. a long-term projection of the effects of problems on society.

The problem of freshwater scarcity in Malaysia needs to be addressed by a group of individuals who can apply their cultural intellectualism towards problem solving as well as those who can look into the future on how to prevent further disasters. This requires long hours of dwelling on the problem and investigating what other countries have done to become successful in overcoming the problem. They should have the drive to influence the implementation of the laws against the unscrupulous dumping of garbage into rivers and the surrounding ecosystem which, in turn, will guide the executive branch of the government towards positive implementation strategies. In Malaysia, universities and research institutes, which supposedly house the experts are disappointingly lacking in the characteristics of an intellectual. There is no doubt that there has been a lot of scientific research into freshwater resources, but this information remains within the rubric of the 'hard' sciences. Social scientists must also yearn to get involved with their fellow academic scientists to work in tandem to overcome the freshwater problem in Malaysia. This is a cocktail for the interdisciplinary approach towards adaptation and mitigation. This can only be done if one has the future foresight, mental curiosity and honesty to solve a problem that could destroy society or even civilizations.

Terms such as insight, understanding, conceptual thinking, image, idea, feeling, reflection, and so on best describes this special group of individuals that Malaysia needs, in order to adapt to climate change and related problems, such as freshwater scarcity. Compared to other members of society, it is the intellectual who uses his/her "mind" the most (Geertz, 1973). The mind of an intellectual is a term denoting a class of skills, propensities, capacities, tendencies and habits; it refers to an active and eager background which lies in wait and engages whatever comes its way (Dewey, 1934). In order to address the problem of climate change and freshwater resources, one must apply the sociology of knowledge, which deals with the social element in the pursuit and perception of truth (Geertz, 1973: 197). The sociology of knowledge is the study of the relationship between human thought and the social context within which it arises, and of the effects prevailing ideas have on societies. It deals with broad fundamental questions about the extent and limits of social influences on individual's lives and the social-cultural basics of our knowledge about the world (Merton, 1969).

Civil society in Malaysia can play a more active role by addressing climate change issues. Intellectuals are part of civil society. They must lead in action-oriented programs in helping to reduce greenhouse gas emissions through their daily activities. They could write articles or newspaper columns, or even be physically involved on the ground. For instance, an intellectual, whether he/she be in the university, a think tank, a government servant or a businessman must be relentless in constantly highlighting the dangers of open burning, the use of aerosols, the non-separation of garbage, i.e. glass from plastic and paper from non-biodegradable objects. It is about time that courses on Climate Change Adaptation and Mitigation be introduced in social science faculties of universities. Many Malaysian universities already have environment-related courses, but none of them focus exclusively on Climate Change, and if there are any, the science faculty has taken hold of the reigns. The social sciences are backward when it comes to such subjects for research and teaching. Being such an important and vital topic for human survival, the course should be introduced as a mandatory course in order for students to graduate. 'Flexible' academics and other facilitators should be the ones to teach. By 'flexible' is meant that the academic or facilitator has to be more inter-disciplinary in his/her approach to the many aspects of the problem of climate change, including adaptation and mitigation. The responsibility of the intellectual is to be focused on the problem, and be consistent in informing society of the dangers of climate change on the daily lives of people. An effective intellectual is one who is grounded in the problem, and has the ease of getting across his/her message in the simplest of languages. "Academic jargon" is superfluous. History shows that intellectuals have probably gotten a bad name among the scientists of climate change discourses due to their focus on theoretical models and 'what was' and what is' but not 'what should' be done. Society wants solutions to problems, not theories on how the problem emerged or how it is progressing. Both scientist and social scientist should work in tandem on this

issue. A member of the Malaysian Youth Climate Justice Network, Adrian Yeo, said the people, especially youths, should be more aware and make their voices heard more often on environmental and climate change issues as these concerned their future (Bernama, Feb. 22, 2011). This is where all stakeholders can instill a culture of intellectualism so that these very youth will grow to be value-enhanced citizens in mitigating and adapting to climate change problems. The methodology is to include the subject in schools, to increase advertisements on the mass media, to increase T. V. talk shows about the problem, harnessing intellectuals as well as scientists and community-based groups who can highlight the problem.

The causal connection between the culture of intellectualism, knowledge and society goes both ways: not only does society shape its knowledge but the reverse holds as well (Dixon, 2009). Also, the spirit to think usually precedes any other change (Alatas, 1972: 166). Knowledge of the sciences such as physics, chemistry, economics, engineering and medicine will not have any considerable effect if they are not related to philosophy and the spirit to think. For example, chemists and engineers study the quality of Malaysia's rivers and come up with statistics to explain the current situation. However, one could enhance such studies by engaging the intellectual to promote the spirit to think about the problem in a holistic manner. What is meant by such a spirit? 1. The desire to know the network of causes comprising a question; 2. Respect for scientific methods; 3. The use of intelligence; 4. The cognizance of interdependence between events, efforts and problems; 5. The possession of confidence, clear and progressive; 6. The ability to think on both a short-term and long-term basis; 6. The capacity to view a question from its whole perspective; 7. The ability to persist when facing any problem.

So, what sort of institutional set up should we have to tackle the problem of freshwater scarcity and climate change adaptation, keeping in mind the role of the intellectual? First, the leadership on addressing global climate change within the NPCC in Malaysia should have a number of intellectuals and academicians on the decision-making panel. The response to climate change correlates with economic, social, domestic and foreign issues. Therefore, the NPCC should establish a National Leading Group to address climate change headed by the Prime Minister, various Ministers concerned with the environment as well as leading thinkers on the subject. The Leading Group will be responsible for deliberating and determining key national strategies, guidelines and measures on climate change, as well as coordinating and resolving key issues related to climate change. The relevant ministries and departments of the government should seriously fulfill their responsibilities, and strengthen coordination and cooperation with all levels of society, so as to achieve synergies to address climate change and freshwater scarcity. Local governments at different levels should also include the intellectual to enhance the organization and leadership on local responses to climate change, and to formulate and implement local climate change programs as a matter of priority.

Next, we should further strengthen the regional administration system for coordinating the work in response to climate change. Measures in this regard include: establishing regional administration agencies to fulfill and implement the national program; organizing and coordinating local activities and actions in response to climate change; building up local expert group on climate change and initiating proper climate change policy and measures according to local conditions such as geographical environment, climatic conditions and economic development levels; lastly, what needs to be done is to strengthen the coordination between national and local governments to ensure the smooth implementation of relevant policies in response to climate change.

5. Concluding Remarks

Malaysia should not cultivate what has come to be known as the *superfluous* intellectual. The latter are described as those who have passively resigned themselves to doing nothing, neither creating nor struggling, but merely feeling alienated and ahead of their time. These are the *abortive* intellectuals. There are many mediums through which intellectuals can be influential. The internet, printed press and online social networks are efficient ways for intellectuals to help in solving the climate change disaster as well as the crisis in freshwater scarcity.

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