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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

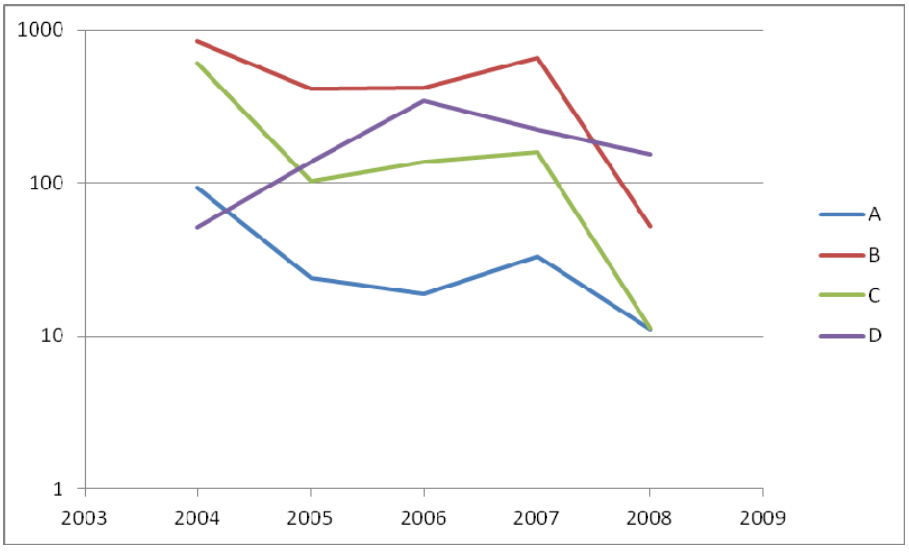

Figure 1 Drastic effects of extreme events on human due to recent hydro-meteorological disasters in malaysia. A = death tolls; B = injured; C = total affected people (in thousand); damage costs (in USD). (*Source :* ADRC Country Report 2008 and 2006, Retrieved from www.adrc.asia.com on 23 December, 2012).

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

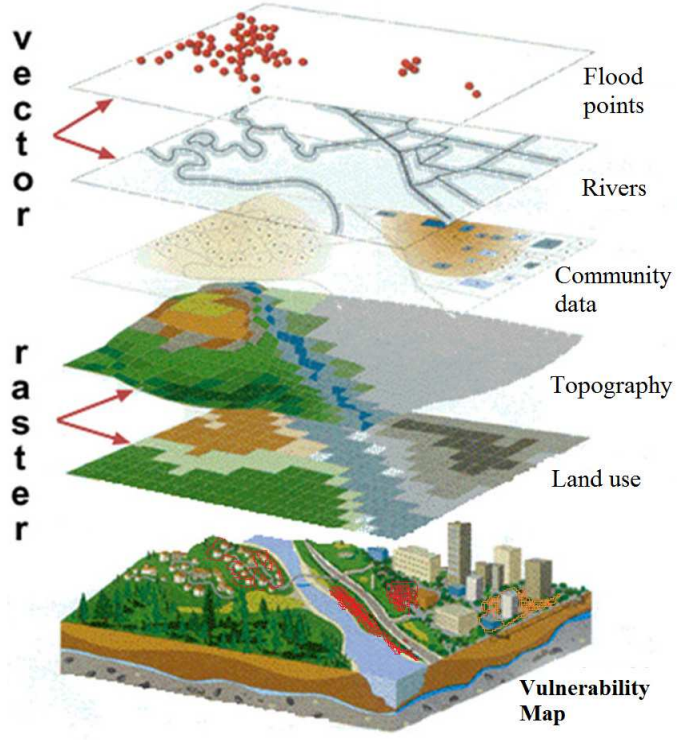

Figure 2 Different layers of information to develop a multi-criteria vulnerability map for flood hazard.

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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