INTERNATIONAL PUBLIC POLICY AND ADAPTATION TO CLIMATE CHANGE IN DEVELOPING COUNTRIES

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Abstract

Adaptation is treated as a pressing need for the developing countries to cope with the climate change realities and International Public Policy regime has a great role to play in it. The study was intended to assess the effectiveness of international public policy in facilitating climate change adaptation in developing countries. Five developing countries, topped in the major indices of vulnerability, from five different climatic zones are selected as cases to ascertain the needs and options for adaptation at the developing countries; and then, international policy initiatives are judged against these identified needs and options. The study asserts that the global climate change adaptation policy is effective in addressing the country need assessments while lags in implementation of those needs. UNFCCC, the main international framework on climate change, initiated adaptation measures that are still prioritizing on the study of national level needs. Though the national studies are very crucial for adaptation measures to be effective, the actions on the ground are even more crucial as climate change is already happening in many parts of the developing world. UNFCCC is responding very slowly to the adaptation measures on the ground due to the shortage of finance and the institutional laggings. The regional co-operation among the states on the climate change stresses is largely absent in the UNFCCC framework that undermines the regional distribution of climate change aspects while the study found that climate change is often a regional phenomenon that cannot be addressed treating the countries individually.

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CHAPTER ONE: INTRODUCTION

1.1 Background

Debates surrounding the issues of climate change, its impacts on humanity and possible ways to address this crisis have received an extensive attention in the last one and a half decade at various international platforms. Traditionally, mitigation i.e. 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system' (Article 2 of UNFCCC, 1992) was taken up as the only approach to combat climate change. However, in recent years, it is realized at the global level especially in the IPCC and UNFCCC that a certain extent of climate change is inevitable regardless of the robustness of mitigation policies in place, primarily due to historical emissions (IPCC, 2001). Therefore, concerns for adaptation have come out as a priority in the discussions of climate change. Adaptation refers to responses to the changing climate and policies to minimize the predicted impacts of climate change (Watson *et al* 1996).

although climate change has already started impacting across the globe, its impacts on developing world is particularly severe vis-à-vis the developed countries as poor countries often lack the technical, financial and institutional capacity to adapt climate changes. UNFCCC, the most important global framework on climate change, recognized the importance of international cooperation on adaptation and called for supports from developed countries to developing countries (article 4 of UNFCCC, 2002). Many experts, especially those form developing countries often allege that the international policy instruments are insufficient to fast-track the process of adaptation to climate change in their countries. In fact, there is no study so far on the issues of international public policy in tackling the challenges for adaptation to climate change faced by the developing countries.

Current study scrutinizes the international public policy regime in terms of the challenges faced by the developing countries in adapting climate change. The policy framework under the UNFCCC and other international instruments dealing climate change adaptation are analyzed against the identified general needs of the developing countries to find any gap at the international policy regime.

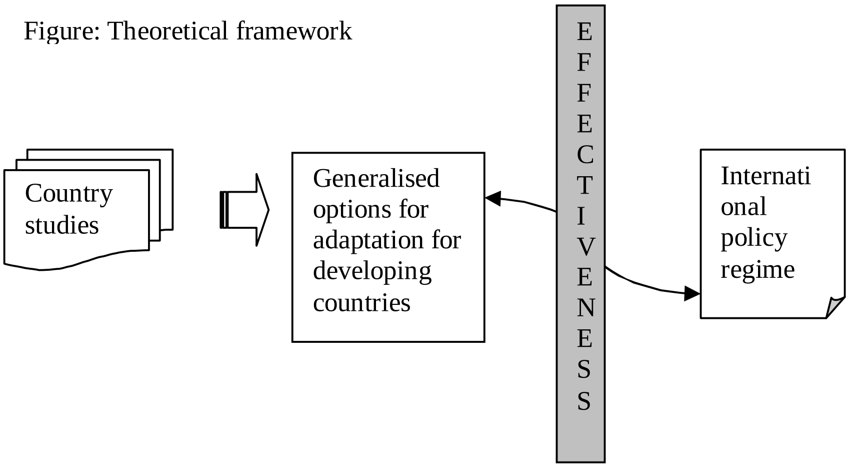
1.2 Research Question

To what extend international policy framework is able to facilitate overcoming the challenges faced by the developing countries to adapt climate change?

1.3 Theoretical Framework

In a nutshell, the study aims to evaluate the effectiveness of the international policy towards developing countries on adaptation to climate change. For this purpose the study adopted a framework that examines the international policy regime against the adaptation needs for the developing world. The research starts with the country-level analysis on climate change scenarios, their impacts on the physical environments and lives and livelihoods and eventually, proceeds with the needs and options for adaptation. These country-level analyses then combines into a set of common adaptation options for developing countries. These common needs and options are then judged against the measures and options taken so far on adaptation at the international level.

Figure: Theoretical framework



1.4 Methodology

Briefly, the research is comprised of two different stages. At the first stage, a need assessment for adaptation for developing countries has been done through agglomerating the findings from selected country studies. In the second stage, an evaluation of the current international policy regime under UNFCCC has been evaluated against the identified needs and options for developing countries.

1.4.1 Selection of Case Studies

Five developing countries are selected for assessing the needs for adaptation to climate change on the basis of their corresponding risks and vulnerabilities to climate change. For this purpose, four well-known indices of vulnerability are consulted to make selection representative.

The Environmental Sustainability Index (ESI) is one of the major indices for understanding vulnerability. The index is a result from the joint initiatives from the Yale Centre for Environment Law and Policy and Centre for International Earth Science Information Network (CIESIN) in collaboration with the World Economic Forum (WEF) and the Joint Research Centre of the European Commission. The index identified the ten most unsustainable countries in 2005 as North Korea, Iraq, Taiwan, Turkmenistan, Uzbekistan, Haiti, Sudan, Trinidad and Tobago, Kuwait, Yemen and Saudi Arabia (ESI, 2005). After 2005, due to the shift of focus by the ESI team, a new index has replaced the old one called Environmental Performance Index (EPI). According to EPI, the most vulnerable countries in 2008 were Niger, Angola, Sierra Leone, Mauritania, Mali, Burkina Faso, Chad, Dem. Rep. of Congo, Yemen, Guinea-Bissau, and Djibouti (EPI, 2008).

The second index, Environmental Vulnerability Index (EVI), devised by the South Pacific Applied Geoscience Commission (SOPAC) and the United Nations Environment Programme (UNEP) categorized the following countries as *extremely vulnerable* (EVI, 2005).

American Samoa	Italy
Singapore	India
Nauru	Cooks island
Guadeloupe	Maldives
Barbados	French Polynesia
Philippines	Trinidad and Tobago
US Virgin Islands	Jamaica
Kiribati	UK Virgin Islands
Saint Lucia	United Kingdom
Fed. States Micronesia	Korea, Rep
Guam	Pakistan
Japan	Bermuda
Netherlands	Austria
Belgium	Malta
Lebanon	Norfolk Island

A third index for climate change vulnerability is developed by Antoinette Brenkert and Elizabeth Malone named Vulnerability-Resilience Indicators Model (VRIM). The authors divide their sample of 102 countries into thirds according to vulnerability (Brenkert and Malone, 2005; 2008). The lowest third is the lists of most vulnerable countries in a descending order as follows:

Sierra-Leone	Nigeria	Pakistan
Bangladesh	Uganda	S-Africa
Somalia	Madagascar	Ghana
Mozambique	Sudan	Nicaragua
Ethiopia	Nepal	India
Rwanda	Haiti	Congo
Benin	Guatemala	Morocco
Yemen	Syria	Honduras
Angola	Kuwait	El-Salvador
Kenya	Swaziland	Cameroon
Senegal	Zimbabwe	Dominican-Republic

The fourth index is the most recent one started publishing in 2008 and also available for 2009 called Global Climate Risk Index (GCRI) authored by Sven Harmeling of *German Watch*- an organization working on north-south equity in the areas of climate change, international trade and corporate responsibility and financial sector sustainability. in 2009, GCRI presents two indices on the severity of impacts of extreme weather events on countries, one for a particular year 2007 and another covering the period of 1998-2007 (Harmeling, 2009). According to the GCRI, the most vulnerable countries for both indices are given below:

Table 1: GCRI Most Vulnerable Counties in the World

Rank	**Country** (on the basis of 2007 events)	**Country** (on the basis of 1998-2007 events)
1	Bangladesh	Hondurus
2	Korea, DPR	Bangladesh
3	Nicaragua	Nicaragua
4	Oman	Dominican Republic
5	Pakistan	Haiti
6	Bolivia	Viet Nam
7	Papua New Guinea	India
8	Viet Nam	Mozambique

9	Greece	Venezuela
10	Tajikistan	Philippines

Source: Harmeling, 2009

Considering all those indices of climate change vulnerability, five most vulnerable countries are selected that are also representing the major vulnerable regions of the world. The countries are Bangladesh, Haiti, Vietnam, Mozambique, and Venezuela. One from South-Asia, one from Small Island Developing Countries (SID), one from East-Asia, one from Africa and one from Latin America while all these countries are listed in the top ten vulnerable countries by the Global Climate Risk Index 2009 and also considered extremely vulnerable in ESI, EPI and EVI indices. The selections of the cases are primarily motivated by the scale of vulnerability, global distribution of risks and availability of secondary resources. In this respect, the selected case studies are methodologically *typical-cases* as they share the similar risks with diversified regional realities.

1.4.2 Assessing the needs and options for developing countries

The cases are proceeded to find out the real concerns, first at the country level and then, at the aggregate level. Impacts of projected climate change scenarios on physical environment, the common criterion the scientific frequently uses, are used for assessing the needs for adaptations at the country level. Each country's adaptation needs then guided to ascertain the options available for adaptation at that country level. There is no clear-cut reasoning for identifying options, still, the whole study of impacts, the thrust sector of the economy on which majority people depends, the severity and frequency of certain calamity and the affordability of the country to adapt are the main criterions that determines choosing of available options. The country-level options for adaptation thus compiled into a common set of options for adaptation that is then used to judge the international regime.

1.4.3 Evaluation of the international policies on climate change adaptation

At this stage, the research evaluates the international policy regime in term of its programme focus on adaptive strategies; the procedures and the policy frameworks vis-à-vis the needs of the developing countries. Evaluation criteria for the international policies are the same ones envisaged in the need assessments and options identifications. A synthesized form of options has been produced from the whole analysis at the country level that forms the basic criterion for evaluation of international policies. Programmes initiated by the UNFCCC are judged against those options. The programmes, their implementation, related finance and institutional aspects are analyzed to get the whole picture of the current regime.

Chapter two: Country Narratives

2.1 Bangladesh

2.1.1 Context, Climate and Environment

Bangladesh is located in the South Asia surrounded by India to the west, north and north-east; by the Bay of Bengal to the south and by Myanmar to the south-east. The total area be 1, 47, 570 sq. km with a total population of 142.4 million (BBS, 2008) gives the density to 964 person/sq. km. - one of the highest densities in the world. The geomorphological situation in Bangladesh is characterized with the location of great *Himalayan* Mountains and *Khasi-Jaintia* hills to the north and the Bay of Bengal and northern Indian Ocean to the south. This unique geomorphology controls and modifies the weather and climate for Bangladesh as well as for the region. This locational aspect causes live-giving monsoon for Bangladesh as well as a number of disasters that are now getting more and more frequent and fierce due to climate change (Ali, 2000; Ahmed and Haque, 2002).

Figure: Map of Bangladesh

Bangladesh has a very flat landscape and low topography while modest areas in the northwest and southwest regions that count in total, only nearly 10% of total area situated above 1m the mean sea level (Ali, 2000). On an average, one-third of the total area is under tidal excursions (GoB, 2008; Hassan *et al*, 2008). Basically, Bangladesh is a deltaic plain evolved from the continuous sedimentation from three mighty rivers originated from of Himalayan mountain series and Khasi-Jaintia hills namely Ganges, Brahmaputra and the Meghna (GBM). These three rivers with their distributaries, tributaries, sub-distributaries and sub-tributaries formed one of the largest river systems in the world that comprises 230 rivers and covers a length of 24,140km (Ali, 2000). These rivers carry a huge amount of water and sediments and causes for surface water flows towards the Bay of Bengal considered as the lifeline for Bangladesh's agriculture and riverine navigation whilst causes for various hazards like floods, erosions and accretions. Available land types of Bangladesh shows that the majority areas except the high lands are exposed to the monsoon flooding for whole or part of the year. Bangladesh has a relatively long coastline that is 720 km long where 28% of total population of the country live (Ali, 2000).

Briefly, the climate of Bangladesh can be characterized with high temperature, sometimes with excessive humidity, heavy rainfall and a significant seasonal variation. The climate is heavily influenced with the flow of summer and winter wind as well as with the post and pre monsoon wind circulations (Rahman and Alam, 2003). Southwest monsoon originates from the Indian Ocean and carries warm, moist and unstable weather while the northeast monsoon blows from Siberia is cool and dry. Although there is remarkable seasonal variance, the country grossly has a uniformly humid, warm, tropical climate all over the country. There are three main seasons: 1) the hot *summer season,* between March and mid-June, is primarily very hot with the highest evaporation and heavy unpredictable rainfalls; 2) the hot and humid *monsoon season,* between mid-June and October, is primarily rainy i.e. responsible for two-thirds of annual rainfall in Bangladesh along with a high temperature; and 3) the cool and dry *winter season,* between November and March, is relatively cooler with very little or no rainfall. Bangladesh records a mean annual mean rainfall of 2300mm with significant spatial and temporal variances. Eastern part of the country has the higher rainfall sometimes crossed over 5000mm while the western part gets only 1200 mm in extreme cases (Rahman and Alam, 2003) .

2.1.2 Projected scenarios of climate change in Bangladesh

Two types of projection for future climate change scenarios are available for Bangladesh. The first one is speculative projection whereby the estimation is done with the 'expert judgements'. The second one is done with the various scientific models, in general, the Global Circulation Model (GCM) used by the IPCC (Ahmad, 2006) as well. Both the projection techniques is concerned with the future climate change scenarios in terms of changes in temperature, rainfall and sea level rise. A summary of all relevant studies on future climate change scenarios in Bangladesh are tabled below:

Table 2: Compilation of projected climate change scenarios for Bangladesh

Type of projection	**Year**	**Temperature change (°C)**			**Rainfall change (%)**			**Sea-level Rise (cm)**	**References**
		Ave.	W	M	Ave.	W	M		
Speculative	2050	0.3-5			5 -20%			100	Mahtab (1989)
	2050 scenario 1 2050 scenario 2	2 4					18 33	30 100	BCAS-RA-Approtech, 1994
	2050 scenario 1 2050 scenario 2	2 4						30 100	Ali, 1999
GCM	2030	0.5-2					10-15		BUP-CEARS-CRU, 1994
	2010 2070	0.3 1.5				 -10-+10	5 5-30		ADB, 1994
	2030 2075	1.3 2.6							Asaduzzaman *et al*, 1991
	2030 2075	1.3 2.6	1.5 2.1	.7 1.7	4.56 15.6	50 -100	11.2 26.7		Ahmed, A.U and Alam, M., 1998
	2030 2050		1.3 1.8	0.7 1.1		-3 -37	11 28	30 50	Mirza, 1997
	2030 2050 2100	1.0 1.4 2.4	1.1 1.6 2.1	0.8 1.1 1.9	3.8 5.6 9.7	-1.2 -1.7 -3.0	4.7 6.8 11.8		Agrawala *et al*, 2003
	2030 2050 2100	1.0 1.4 2.4	1.1 1.6 2.1	0.8 1.1 1.9	5 6 10	-2 -5 -10	6 8 12	14 32 88	NAPA (GOB) 2005

Note: W stands for Winter and M stands for Monsoon, positive numbers denotes for increase and negative for decrease. *Source: compiled by the author from Ahmed, 2006; Ali, 1999; Agrawala et al 2003 and GoB, 2005*

In summery, both the GCM and speculative models assert that the temperature will continue to be rising roughly by 2°C by the next 60 years. Average rainfall is predicted to increase in monsoon and decrease in winter by 12-15% and 3% correspondingly by 2030. Sea Level Rise (SLR) will be 30cm by 2030.

2.1.3 Physical Impact of Climate Change

1. Floods

The geographical location, dependency on the GBM hydrology and climatic situation at the Himalayans, flat topography and variability in seasonal rainfall make Bangladesh a exceptionally susceptible to the extreme water related disasters like floods. As a country situated in the lower stream, Bangladesh receives a huge amount of discharged water from upstream GBM catchments resulted from heavy rainfall and melting of glassier at the Himalayans (Hassan *et al*, 2008). This huge discharge is often coupled with the heavy rainfall inside the country in the monsoon. The flat floodplain with a very low gradient, cannot afford to drain such a huge amount of water to the Bay of Bengal. The discharge of water sometimes also delayed due to tidal surge and storms in the coastal areas (Ali, 2000). All these conditions often altogether translated into devastating floods in Bangladesh. Rise of temperature due to climate change and the increase of rainfall in monsoon will contribute to worsen the situation.

Given the scenarios of climate change, the susceptibility of flooding in Bangladesh would be increased both in terms of frequency and intensity. Predicted incrased rainfall in the monsoon by 12-15 percent by 2030 is particularly causative for *Rainwater floods*[1] in Bangladesh. The severity of the floods will be higher with the increased watering and duration could be prolonged with the potential sea-level rise. The so-called *back water effects*[2] caused by the rise of the sea level would contribute to impede the drainage of river water into the Bay of Bengal.

The predicted temperature rise by 1.5^0 C by 2030 in the region will contribute to an increased melting of glassier and snow at the high-Himalayans and thus, will cause an increased flow of water in the rivers in Bangladesh. Increased river flow will be coupled with the increased rainfall in the upstream as well as in the country at the same time, which will give tremendous pressure on Bangladeshi rivers for discharging an extraordinary amount of water. Eventually, that would be translated in the so-called *River floods*[3]. In the same way, increased rainfall in the catchments will be contributing to the increased susceptibility of *flash floods*[4] as there will be huge amount of water flows into Bangladesh from the Himalayans.

Studies also suggest that the existing land type would also be altered with the increased susceptibility of floods in Bangladesh. Bangladesh has five major types of land according to annual flooding. Due to excessive watering through rainfall and floods, the proportion of high land (F0) would decrease while the other types of lands like F1 and F2 that are prone to seasonal flooding would go increasing. Studies show that under the current prediction of climate change, about 18 percent of the current low-flood-prone area would be coming under

[1] Flood caused by excessive rainfall inside the country (Ahmed *et al*, 2000).
[2] Back water effect refers to the retardation of a river outflow by a rise in the level of water at the river mouth. The effect may be from a main river to its tributary or from a sea to a river (Ali, 2000)
[3] Causes mainly by overflowing of rivers due to an increased discharge of water from the upstream.
[4] Temporary types of flood results from the excessive discharge of water from the upstream within a very short period (Ahmed *et al*, 2000).

flooding. In an average, 12 or 16 percent of new land would become susceptible to varied degree of flooding (Alam *et al*, 1997 *cited in* Rahman *et al*, 2007).

2. Coastal cyclones and storm surges and salinity

Climate change is likely to increase both the frequency and intensity of coastal cyclones. Studies suggest that the rise in the sea level (SLR) and the subsequent increase of Sea Surface Temperature (SST) would contribute to increased occurrences and intensity of cyclones. Northern Indian Ocean, especially the Bay of Bengal is a breeding ground for furious cyclones while a number of them die in the middle of the ocean. In the scenario of an increased SST, these cyclones will be hitting the coast. Estimations assert that the number of land-falling cyclone would be increased by 32% in the Bay of Bengal (Ali, 2000; Ali, 1999) and in general, intensity may increase by 4%, 10% and 22% as SST rises 1^0 C, 2^0 C and 4^0 C respectively (Emanuel, 1987).

Coastal cyclones always come with storm surges. An increase in cyclone intensity will contribute to the corresponding increase in the height of storm surges. study shows that the surge height will be 21% more as the SST increased by 2^0 C and 47% for 4^0 C contributing to a horizontal expansion of the coastal flooding. The study also asserts that the inland penetration of surge will increase by 13% and 31% respectively for 2^0 C and 4^0 C SST increases (Ali, 1996 *cited in* Ali, 2000).

As the country is very low lying, SLR and coastal flooding will inundate more and more coastal lands. This will increase the salinity, especially in the winter when there will be less water flow from the uplands due to reduction of precipitation.

3. Droughts

Winter in Bangladesh is nearly rainless accounts only 3% of the total rainfall of the country (Rahman and Alam, 2003). The climate change scenarios assert that there will be a further reduction of the rainfall in the winter as the evapo-transpiration will increase due to increased temperature. Estimations suggest a 20-30 percent reduction of the winter rainfall by 2030. This will lead vast areas of north western region to sustained drought conditions. Under severe climate change scenarios, drought may increase from 4000 sq. km to 12000 sq. km (Huq *et al,* 1996 *cited in* Ahmed, 2006).

4. Erosion

Riverbank erosion in Bangladesh is very usual as most of the rivers flow through Ganges-Brahmaputra-Meghna floodplain that is built as unconsolidated sediments and thus, prone to erosion. If there is more water in the rivers there will be more susceptibility of riverbank erosion. Climate change scenarios suggest that the heavy rainfall and huge discharge of upstream water will contribute to a rise of the water level in the rivers that would accentuate riverbank erosion. Besides riverbanks, erosion in the coastal region is also predicted as Sea Level Rises. About 2,500, 8,000 and 14,000 sq. km of land i.e. a percentage of 2%, 5% and 10% of total land area in Bangladesh will be vanished due to SLR of 10cm, 30cm and 100cm respectively (Ali, 2000; Ali, 1999)

2.1.4 Need for Adaptation

In the backdrop of major impacts of climate change on physical environs, the need for adaptation is felt crucial. For analysing the adaptation need the study was attempted to analyze the physical impacts of climate change with the developmental need of the country. Following table summarises the development challenges due to climate change.

Table 3: Need for Adaptation in Bangladesh.

Challenges/ Issues	Climatic reasons (Why?)	Extend
Crop failure and food security	▪ Increased frequency and intensity of flood ▪ Sea level rise ▪ Increased salinity	In moderate scenario rice production for *Aus, Aman* and *Boro* will be reduced by 27%, 13% and 7% while wheat production will reduce by 61% (Karim *et al*, 1996 *cited in* Ahmed 2006)
Aquaculture	▪ Increased frequency and intensity of flood	-
Coastal shrimp culture	▪ Stronger and higher storm surges ▪ increased salinity ▪ Rise in the SST	-
Livestock	▪ rise in the cyclonic storm surge ▪ increased salinity in the coastal area	
Human Health	▪ Temperature rise.	increase parasites like mosquitoes and will contribute to malaria, dengue etc
Settlements and infrastructure	▪ Increased foods, cyclones and storm surges	Flood alone will damage to national highways at 1011 and 3315 km and to embankments at 4271 and 13996 km in the year 2030 and 2050 respectively (BRTC-BUET, 2005 *cited in* Ahmed 2006).
People's livelihoods	▪ Crop failure, deterioration of food security, damages on settlements and increase of water borne diseases.	
Migration	▪ due to erosion and increased disasters in the coasts and riverbanks	

Source: Author's own compilation, 2009

2.1.5 Options for Adaptation

In line with the identified impacts and threats the available adaptation measures are summarised below:

Table 4: Options for adaptation for Bangladesh

Adaptation measures	Why

1. Early warning system	▪ to make prepare the people for disaster, rainfall, water level and threats for agriculture
2. Crop Insurance	▪ insurance for crop failure
3. Riverbank Protection	▪ to protect people from erosion and small floods
4. Adaptive technology	
- disaster tolerant settlements	▪ to protect home from cyclones
-saline, food and drought tolerant crop varieties	▪ to adapt coastal agriculture
-alternative cropping pattern	
- non-traditional fisheries	▪ for agriculture and food
	▪ for fisheries
5. Improvement of Drainage system	▪ to protect floods
6. Coastal afforestation	▪ to build natural shields against cyclones
7. construction of resilience infrastructure to climate change	
8. Awareness building	
9. Research and Institution building	

Source: Author's own compilation, 2009

2.2 Vietnam

2.2.1 Context, Climate and Environment

Vietnam, eastern part of the Indochina peninsula, is located in the Southeast Asia bordering China to the north, Cambodia and Laos to the west, the Gulf of Thailand to the south and southeast, and South China Sea to the east. The total area is 331,688 sq. km populated with 86 million gives the density of 253 person/sq. km. A total of 3,260 km coastline is facing to South China Sea and to the Pacific Ocean to the east and south. The country is shaped like a narrow strip of land facing towards the seas. The highest width of the strip is 500 km and the lowest is 50 km. The running of the rivers through this narrow distance to basin is very critical that climate change would be making more problematic (ADPC, 2003).

Figure: Map of Vietnam

The country landscape is made up of hills, mountains, deltas and coastlines. Hills and mountains with elevation between 100 and 3400m occupy three forth of the total land. Topography can be divided into three different regions: northern, central and southern. Northern region is primarily hilly except for Red River delta. Central region is full of mountains called *Giai Truong Son* while the southern part comprises coastal lowlands and the Mekong River delta (ADPC, 2003; CCFSC, 2001). The plain areas primarily comprise of two major deltas- Red River delta in the north and Mekong River delta in the south (Choudhry and Ruysschaert, 2007). These deltaic plains are the fertile lands and most of the agricultural production and industrial establishment concentrated here.

The country enjoys a tropical monsoon climate characterized with heavy rainfall. Seasonal variation and intensity of rainfall depends on monsoon. Average mean temperature varies between 18 and 29 ^{0}C. Annual average rainfall across Vietnam varies from 1800 to 2500mm, while some regions enjoy as much as 5000cm. More than 70 percent of the rainfall occurs during the rainy season between May and October. a wide network of rivers originates from the western hills discharges rain waters to the sea. Among the nine major rivers, Mekong and the Red river dominate with the amount of discharging water and with the area of their basins (ADB, 2009; Choudhry and Ruysschaert, 2007; Dharmaji and Huy, 2008).

2.2.2. Projected Scenarios of Climate Change in Vietnam

1. Increase in Temperature

Projections show that the increase of temperature by 2070 would be up to 2.5^{0} C with regional differences. Inland regions would observe a higher increase of temperature while the costal area would observe much less increase (NOCCOP, 2002 *cited in* ADPC, 2003). temperature increase would be 1.4-1.5^{0}C for 2050 and 2.5-2.8^{0}C for 2100 (Choudhry and Ruysschaert, 2007).

Table 5: Projected Temperature Increase in Vietnam

	Region	2010	2050	2070
Inland	Northwest, North	0.5	1.8	2.5
	Highland	0.5	1.8	2.5
Coastal	Northern Plain	0.3	1.1	1.5
	Central	0.3	1.1	1.5
	South	0.3	1.1	1.5

Source: NOCCOP[5], 2002 (adopted from ADPC, 2003)

Oxfam's study asserts that average temperature would be increasing by 1-2^0 C by 2050 and by 2-3^0 C by 2100 over the pre-industrial level (Oxfam, 2008). ADB also asserts in a very recent study that Vietnam temperature would be increased of 2–4ºC by 2100 (ADB, 2009).

2. Rainfall Changes

The increase of annual rainfall would be 2.5-4.8 percent and 4.7-8.8 percent by 2050 and 2100 respectively. Highest increase in rainfall will be observed in the northern region while least in the southern plains. Rainfall will be increased in the rainy season and decreased in the dry seasons and lot more rain in the rainy season (Hoang and Tran, 2006 *cited in* Choudhry and Ruysschaert, 2007*)*. The flow of water in the two main rivers of the country, the Mekong River and the Red river, in the rainy season is expected to rise by 7-15% than the base year (Oxfam, 2008). According to ADB, the average rainfall will increase by 5-10% by the end of the century. However, southern Vietnam will be drier as the increased rainfall will be concentrated in the northern and central part of the country (ADB, 2009).

3. Sea level Rise

[5] National Office for Climate Change & Ozone Protection, Vietnam

Finding shows that there will be a rise in the sea level by 9 cm in 2010, 33 cm in 2070, and by cm in 2100 (Choudhry and Ruysschaert, 2007). Oxfam asserts that the sea level rise will be of 30 to 35 cm for 2050, 40 to 50cm for 2070 and 60 to 70cm for 2100 (Oxfam, 2008). IPCC 4th assessment report concludes with 69-100cm rise of sea level by 2050 for Vietnam (Dharmaji and Huy, 2008). ADB predicts an annual rise of 2-3 mm (ADB, 2009).

2.2.3 Physical Impact of Climate Change

1. Floods and Droughts

As stated earlier, due to climate change rainfall pattern and intensity are expected to be changed. These changes in precipitation will primarily contribute to a more intense water flow in the rainy season and a prolonged aridity in dry season (ADPC, 2003). The increased rainfall will not arrive in required time rather will come in a time when the country will be fighting against floods, and eventually will contribute to the increased susceptibility of flood and droughts.

Given the possible climate change scenarios, the Red River basin and the Mekong Basin are particularly vulnerable to flooding in the rainy season and drought in the dry season where 70 percent of agriculture and most of the industries is set-up. It is projected that the water flow would increase in rainy season by 35-41% and 15-19% for basin and delta respectively for Mekong while it would decrease in dry season by 17-24% and 26-29% respectively for the same (IPCC, 2007). These scenarios implied that there will be an increased risk of floods in rainy season as well as a likely shortage of water in the dry season.

Potential sea level rise would also have very disastrous impacts on the basins. a meter of sea level rise would contribute to flooding of a half million sq. km of red river delta and 20000 sq. km of Mekong river delta (IPCC, 2007; Dharmaji and Huy, 2008) including a thousand sq. km of cultivated farmland and a loss of 2500 sq.km area of Mangrove forest, the home of invaluable biodiversity and a major source of national income (IPCC, 2007; ADB, 2009). World Bank estimated that 11 percent of the total population i.e. nearly 10 million and a GDP of 10 percent would be impacted by a sea level rise of 1 meter (Dasgupta *et al*, 2009) since a high percentage of population and economic activity is concentrated in the two major deltas.

2. Typhoons

For its location, Vietnam is considered as one of the most vulnerable place of typhoons. Typhoon, a kind of tropical cyclone is historically very recurrent in Vietnam as it lies at the centre of the South China Sea- one of the most active typhoon centres in the world. Historically 80% of total natural disaster in Vietnam is caused by typhoon (McSweeney *et al*, 2008). Given the climate change scenarios, it is not clear until now how the typhoon intensity and frequency will be influenced, but there is a common consensus that coastal zone and northern part of the country will be the worst sufferer with a greater intensity of typhoon due to rise in sea surface temperature and sea level (IPCC, 2007). As the occurrence of typhoons will increasingly coinciding with rainy season due to changes in sea surface temperature dynamics, the magnitude of these typhoons would be more intense (CCFSC, 2001 *cited in* Choudhry and Ruysschaert, 2007).

3. Erosion, Saline Intrusion and Forest-Fire

Coastal erosion and the potential loss of mangrove forest is one of the obvious impacts of sea level rise in Vietnam. The coastal flooding with tidal surge will also increase salinity in the region. Vietnam is very prone to forest-fire incidences and the increased temperature will increase the probability of forest-fires in the dry season.

2.2.4 Need for Adaptation

In light with the analysis of projected climate changes and its impacts on physical environs, the following adaptation needs are identified for Vietnam.

Table 6: Adaptation Needs for Vietnam

Challenges/ Issues	Climatic reasons (Why?)	Extend
Agriculture	▪ Increased frequency and intensity of flood ▪ Sea level rise and Increased salinity in the coastal areas ▪ Extended droughts in the south coast ▪ Increased frequency and intensity of typhoons	By 2050, yield will decrease by 3- 6 percent for summer rice while 17 & 8 percent for spring rice in the north and south respectively. Maize yield also decease generally (Nguyen *et al.* 2005 cited in Choudry and Ruysschaert, 2007)
Forestry and Biodiversity	▪ Increased erosion ▪ Increased intensity and duration of dry season	Vietnam is very susceptible of forest fires and the increase duration of dry season will accentuate the threat (IFAD, 2008). The mangrove forest, would be also losing its 2500 sq.km of area (IPCC, 2007; ADB, 2009)
Human Health	▪ temperature rise will increase parasites like mosquitoes and will contribute to malaria, dengue etc.	
Aquaculture and fisheries	▪ Due to Degeneration of Coral reefs, sea fish habitat will disappear. ▪ Rise of sea level ▪ Intrusion of salinity ▪ Reduction of mangrove area	By 2050, Economic value of production from fisheries and aquaculture will be reduced by at least one third (Choudry and Ruysschaert, 2007)
People's livelihoods	▪ Crop failure, deterioration of food security, damages on settlements and increase of water borne diseases.	

Source: Author's own compilation, 2009

2.2.5 Options for Adaptation

In line with the identified impacts and threats the available adaptation measures are summarised below:

Table 7: Possible Measures of Adaptation for Vietnam

Adaptation measures	**Why**
1. Disaster early warning system	▪ to combat forest fires ▪ to combat floods
2. Coastal management - land use policies - zoning in coastal areas - minor infrastructure	▪ prevention of erosion ▪ protection against inundation ▪ flood protection
3. Coastal afforestation and community fire management	▪ to build natural shields against cyclones ▪ to combat forest fires
4. Adaptive technology	
-saline, food and drought tolerant crop varieties	▪ to adapt coastal agriculture
-alternative cropping pattern	
- non-traditional fisheries	▪ for agriculture and food ▪ for fisheries
5. water management and improved irrigation system	▪ to combat drought
6. Awareness building	
7. Research and Institution building	

Source: Author's own compilation, 2009

2.3 Mozambique

2.3.1 Context, Climate and Environment

Mozambique, one of the poorest countries in the world is located in the south-eastern Africa bordering Tanzania to the north; Malawi, Zambia and Zimbabwe to the west; South Africa and Swaziland to the south and Mozambique Channel and Indian Ocean to the east. Total area comprises of 799380 sq. km with a population of 21.6 million that gives the population density 25 per sq. km- one of the lowest in the world. Physiographic significance of Mozambique is characterized by the presence of a very long coastline to the east, facing towards Mozambique Channel and Indian Ocean. The coastline is 2700 kilometre long with a number of small islands on it. The presence of such a long coastline where 60 percent of the total population live is one of the critical areas regarding climate change in Mozambique.

Topography of Mozambique includes flat coastal lowland, highland and mountains. Forty-four percent of total land area is coastal lowlands across the east-coast. As progresses towards the west the elevation of lands gets higher and at the far west border the elevation is the highest with high mountains. Mozambique's coast can be divided into three distinct regions- the *central region* holds a wide, flat and fertile coastal plain that is blessed with a number of large rivers and deltas; the *southern region* is a semi-arid or arid coastal plain with some large rivers; and the *northern region* is a narrow plain with a few large rivers holds sandy beaches and coral reefs (INGC, 2009). The most important rivers are the Zambezi, runs across the centre of Mozambique; the Limpopo, runs through the south, the Sabi, flows at the centre; and the Lugenda, streams in the north. Zambezi River is the fourth largest river in Africa runs a long way through Tanzania, Malawi, Zambia, Angola, Namibia, Botswana and Zimbabwe before entering into Mozambique. It discharges a huge amount of water from the upstream regions and falls into the sea after crossing a large part of Mozambique (MICOA, 2007)

Figure: Map of Mozambique

The country enjoys tropical climate that comprises of two main seasons. The hot and humid *wet season* falls between October and March and the cool *dry reason* falls between April and September. Temperature of the country varies with the latitude: the lower the latitude the higher the temperature. Average temperature in the southern coast is 24- 26^0 C. Average rainfall varies from 400mm to 2000 mm from region to region. Northern side of Zambezi River enjoys the highest rainfall and has got a visible rainy season while the southern region gets the lowest rainfall and prone to drought. Central region has the moderate rainfall (MICOA, 2007; MICOA, 2003).

2.3.2 Projected Scenarios of Climate Change in Mozambique

1. Increase in Temperature

The mean temperature increases for Mozambique will be 1.8-3.2^0C by 2075 (MICOA[6], 2007). The increase of temperature also has a significant regional and temporal divergence. GCM models predict that the highest increase will occur in the months of September-November and in the Inlands with a maximum increase of 2.5-3.0^0C by 2060 (IPCC, 2007). By 2080-2100, temperature can be increased by 5-6^0 C in the central region in September-November period (IPCC, 2007)

2. Changes in Precipitation

Initial communication of Mozambique government to UNFCCC asserted that there will be a reduction of rainfall by of 2-9% in 2075 (MICOA, 2007). However, the most recent GCM

[6] Ministry of Coordination of Environmental Affairs

model exercise could not establish any clear-cut trend of decrease or increase of precipitation for Mozambique (IPCC, 2007).

3. Sea Level Rise (SLR)

Average sea level rise for Mozambique is estimated to be of 93mm by 2100 (MICOA, 2007). Some models examine two possible scenarios against sea level rise in Mozambique; the best case scenario (low sea level rise) and worst case scenario (high melting in the polar) (INGC, 2009). Following table summarises the two scenarios with corresponding time series.

Table 8: Sea Level Rise in Mozambique

Scenarios	**2030**	**2060**	**2100**
Best case (low sea level rise)	10cm	20cm	30cm
Worst case (high sea level rise)	10cm	100cm	500cm

Source: INGC, 2009

2.3.3 Physical Impacts of Climate Change in Mozambique

1. Droughts

Central and southern region of Mozambique is prone to drought. These areas are characterized with low precipitation, and a constant shortage of water. Predicted temperature rise and the further shortfall of rain would accentuate the situation of drought in Mozambique. Temperature wise increase evaporation and evapo-transpiration coupled with a reduction of rainfall in the central and southern region will contribute to a sustained drought and desertification situation. Climate change will certainly intensify drought situation that is already common is south and possibly lasting for three to four years in every occurrence (CARE, 2006; INGC, 2009; MICOA, 2007).

2. Coastal Cyclones and Flooding

Mozambique is prone to coastal cyclones originating from the Indian Ocean that is predicted to increase both in frequency and intensity, given the projected climate change scenarios. The main period of cyclones in coast is normally October-April while the intensive cyclones hit the coast during February –April. Sea level rise and the sea surface temperature wise will contribute to the increase of the land-falling cyclones in the coastal region and the intensity will be much higher with the higher tidal surge and rainfall along with the cyclones. Major sea port in the central region call *Beira* would be very vulnerable and in extreme scenario of sea level rise, could be disintegrated from the mainland (INGC, 2009). A vast area of central coastline is subjected to coastal flooding even for a moderate sea level rise. Southern Maputo and Limpopo areas are exposed to floods. Most of the southern region will be troubled by cyclones because of very flat coastline. Northern region of the country is relatively safe from coastal surge and cyclones (INGC, 2009).

3. Saline Intrusion and Erosion

Saline intrusion in the inlands is a major problem for Mozambique in the wake of climate change. Sea level rise and coastal flooding will couple with low rainfall; will eventually contribute to an increase in salinity in the coastal region. Increased phenomenon of inundation will also contribute to the coastal erosion. Increased intensity of ocean tides due to sea level rise and frequent cyclones would lead to a severe invasion of salt sea water in the major river systems. The major river Zambezi will be affected worst in terms of areas while river like Siba will be affected more severely as its discharge of fresh water is normally very low. This salt water incursion will disastrous for already problematic drinking water situations in Mozambique (INGC, 2009).

2.3.4 Need for Adaptation

The adaptation needs for Mozambique from the analysis of impacts are following:

Table 9: Need for Adaptation for Mozambique

Challenges/ Issues	Climatic reasons (Why?)	Extend
Agriculture and food security	▪ Increase salinity and erosion in the main agricultural region ▪ Sea level rise and frequent inundation ▪ Extended and intensified droughts. ▪ Increased frequency and intensity of coastal cyclones	GCM models show that there will be a decrease of yield while it also shows that this yield failure can be counterbalanced by intensification of agriculture[7] and technological improvement (World Bank, 2008a).
Drinking and irrigation Water	▪ Increased salinity in the river system ▪ Extended and intensified droughts.	-
Human Health	▪ Temperature rise will increase parasites like mosquitoes and will contribute to malaria, dengue etc. ▪ Epidemics of diarrhoea and cholera due to drinking water problem and disaster.	-
Aquaculture and fisheries	▪ Due to Degeneration of Coral reefs, sea fish habitat will disappear. ▪ Rise of sea water level ▪ Intrusion of salinity	-
People's livelihoods	▪ Crop failure, deterioration of food security, damages on settlements and increase of water borne diseases.	-

Source: Author's own compilation, 2009

2.3.5 Options for Adaptation

In line with the identified impacts and threats the available adaptation measures for Mozambique are summarised below:

[7] In Mozambique there is a huge scope of new cultivation as only 10 % of total land is in productive use (World Bank, 2008a)

Table 10: Options for adaptation for Mozambique

Adaptation measures	Why
1. Land Use planning and inclusion of agricultural lands	▪ to include non-cultivable lands into cultivation for agriculture production and food security
2. Alternative water management system	▪ to ensure drinking water for the people ▪ to facilitate irrigation system in the drought areas ▪ to facilitate new agriculture
3. Adaptive technology -saline, food and drought tolerant crop varieties -alternative cropping pattern - non-traditional fisheries	▪ to continue cultivation and fisheries production in the climate change conditions.
4. Improved drainage system	▪ to combat floods in the rainy season ▪ to discharge saline water back to the sea
5. Resilient infrastructure for ports and settlements	▪ to protect major sea-ports and urban infrastructure
6. Early Warning System	▪ to make prepare the people for disaster, rainfall, water level and threats for agriculture
8. Awareness building	
9. Research and Institution building	

Source: Author's own compilation, 2009

2.4 Haiti

2.4.1 Context, climate and environment

Haiti is a Small Island developing country (SID) located in the Caribbean. Haiti and Dominican Republic shares the second largest Island in the Caribbean known as *Hispania*. Haiti is located in the west side of the Island occupying one third of Hispania accounting of 27750 sq. km. The country is surrounded by water-body from three sides with only exception in the east as bordering Dominican Republic. It surrounds The Atlantic Ocean to the North and the Caribbean Sea to the West and South. Haiti has a population of over 10 million that makes the average population density of the country to 292 per sq. km. Haiti is remarkable for its location in a very high latitude from the sea level and that is one of the major causes for facing a number of disasters over the decades and climate change certainly will accentuate the vulnerability of the country to more disasters in the future.

Topography of Haiti is primarily mountainous. Three major mountain ranges extend across the country. There are small fertile plains and valleys between the mountains. Haiti's terrain consists of two peninsulas called southern and northwestern peninsula divided by the *Golfe de la Gonâve*. The country has a 1500 km long coastline that is very irregular and rugged. There are also some small islands along this coastline. Major agricultural activities and traditional fisheries are concentrated in the coast. Haitian tourism and industrial development is also very much dependent on its coast. The longest river of Haiti is partly navigable.

Figure: Map of Haiti

Haiti has a hot, humid and partly tropical climate. Temperature widely varied by elevations. Temperature ranges from 24°C in January-February to 28°C in July-August. Average temperature in the mountainous area is low and in coast is high. Average annual rainfall is 1200mm with a remarkable temporal and regional difference. Some areas have two rainy seasons while some areas don't have any. Northwestern peninsula is particularly dry while southern peninsula, northern plains and mountains are relatively wet. Southern peninsula is also more prone to hurricanes than other areas.

2.4.2 Projected Scenarios of Climate Change in Haiti

1. Temperature Changes

The predicted temperature rise for Haiti according to the first national communication to the UNFCCC, is 0.8 ^{0}C-1^{0} C by 2030 and 1.5-1.7 ^{0} C by 2060 (WB, 2008b). The highest increase of temperature will be in June to October. IPCC predicts the temperature rise will be 0.48-1.06 ^{0} C, 0.79-2.45 and 0.94-4.18 for the period of 2010-2039, 2040-2069 and 2070-2099 respectively (IPCC, 2007) for the Caribbean SIDs.

2. Changes in Precipitation

Though there is no clear cut estimation can be found, the majority of the GCM models predict that the precipitation will be reduced. According to the government estimation, the first communication to the UNFCCC, there will be a decrease of precipitation by 5.9-20 percent in 2030 and 10.6- 35.8 percent in 2060. The highest decrease in precipitation in Haiti would be in the months of June-July that coincides with the rise of the temperature. IPCC estimates a range of changes in precipitation for the Caribbean region that shows increase as well as decrease in precipitation in this region while the overall prediction signals for a decrease in average rainfall in the region. It estimates (-) 14.2 to (+) 13.7, (−) 36.3 to (+) 34.2 and (−) 49.3 to (+) 28.9 for the period of 2010-2039, 2040–2069 and 2070–2099 for the Caribbean (IPCC, 2007).

3. Sea Level Rise

There is no study on the possible sea level rise in Haiti due to climate change, however, regional studies on climate change, in general, predicts that sea level will be rising for the

Caribbean similar to the world average (CDB, no dates). IPCC predicts, for Caribbean, a rise of sea level by 26-59 cm for A1F1[8] scenario and by 18-38 cm for B1[9] scenario by 2099.

2.4.3 Physical Impacts of Climate Change on Haiti

1. Droughts, Floods and Water Stresses

Haiti is prone to droughts. Especially the northwestern part of the country is particularly dry and a predicted decrease in precipitation would accentuate the problem of water crisis in this region. The already impacted agriculture of this region by soil erosion (through excessive deforestation) will become more vulnerable due to climate change. The contrasting scenario prevails at the southern part of the country where heavy rainfall with two rainy seasons occurs. This region is affected by flash floods and tidal surges. As the gradient of the rivers are very sharp in the mountains water comes very quick to the flat low lands and cause devastating floods. Sea level rise and increased inundation in the coastal flat land will contribute to the increase of intensity and duration of foods in the southern region.

2. Cyclones, Saline Intrusion and Coastal Erosion

Haiti is one of the serious victims of cyclones. It lost its invaluable forest resources though unruly deforestation. In 1923, 60 percent of total land area was occupied by forests, while, by now, it becomes only 1 percent. Such deforestation exposed entire coastal belt and river basins to tropical cyclones. Climate change induced Sea level rise and sea surface

[8] A rapid economic growth, global population that peaks in 2050 and declines thereafter and an intensive use of fossil fuel (UNEP, 2001)

[9] A convergent world with a change is economic structure towards a service and information economy, a reduction in material intensity, and introduction of clean technologies. (UNEP, 2001).

temperature increase will contribute to more frequent cyclones. These cyclones will be more devastating as forest like natural protection has been demolished. Majority of the agriculture and other economic activities including tourism is concentrated to coastal areas would be at great danger with the increased frequency and intensity of cyclones. Frequent inundation of coastal areas with the increase salinity due to tidal surge along with the storm is also predicted. Recent research made known that the southern peninsula, the highly dense region with poor slum dwellers, face a heightened risks for hurricanes (ICG, 2009).

2.4.4 Need for Adaptation

The need for adaptation for Haiti from the above analysis is summarised below:

Table 11: Need for adaptation for Haiti

Challenges/ Issues	**Climatic reasons (Why?)**	**extend**
Agriculture and food security	▪ Increased drought in the northwest ▪ Increased food in the southern region ▪ Cyclone and the saline intrusion in the coaster fertile lands ▪ Land erosion due to flash flood	
Water crisis	▪ Increased drought and salinity	-
Infrastructure and coastal biodiversity	▪ Stronger and higher storm surges ▪ increased salinity ▪ Rise in the SST	-
Tourism	▪ Cyclone and increased risk of inundation ▪ Beach erosion ▪ Infrastructure damage caused by cyclones	
People's livelihoods	▪ Crop failure, deterioration of food security, damages on settlements and increase of water borne diseases.	

Source: Author's own compilation, 2009

2.4.5. Options for Adaptation

In line with the identified impacts and threats the available adaptation measures are summarised below:

Table 12: Options for Adaptation for Haiti

Adaptation measures	Why
1. Coastal Afforestation	▪ to build natural protection from hurricanes. ▪ To protect erosion.
2. Alternative agriculture	▪ To adapt an alternative agriculture suitable in the hilly areas
3. Adaptive technology	
- disaster tolerant settlements	▪ to protect home from cyclones
-saline, food and drought tolerant crop varieties	▪ to adapt coastal agriculture
-alternative cropping pattern	
- non-traditional fisheries	▪ for agriculture and food ▪ for fisheries
4. construction of resilience infrastructure to climate change	▪ to protect the infrastructure from small shocks from the sea level rise and salinity
5. Awareness building	
6. Research and Institution building	

Source: Author's own compilation, 2009

2.5 Venezuela

2.5.1 Context, Climate and Environment

Venezuela is located in the northmost part of the South America bordering Columbia to the west, Brazil to the south, Guyana to the east and Caribbean Sea to the north. Country's 28.2 million people reside in 916,445 sq. km gives the population density only 32 per sq. km. - one of the lowest in the world. Geomorphologically Venezuela is a part of northern Andes, one of the major features that dictate the climatic condition in Venezuela. Moreover, the exposures of the northern part to the Caribbean Sea also very crucial in determining the country's vulnerability to climate change.

Figure: Map of Venezuela

Topography of Venezuela comprises of wide varieties of landscapes. Depending on the topography and mountain systems, Venezuela can be divided into four districts regions. The *mountain region* is the extension of Andes run through the northwest part of the country and continues to the northern Caribbean coast. The *Orinoco Basin*, characterized by the *Llanos* (huge area of grass-covered land), occupied the central region of the country stretching from the western forests (as far as the Columbian border) to the east at Orinoco river delta. Orinoco basin is mainly alluvial and fertile lands bind the major important rivers of the country. The *Guiyana Highlands* is the largest region of the country located to the south of Orinoco River and hosts the northern end of Amazon Basin with the great Angel falls, the highest waterfall in the world. The *Marachibo lowlands* is located in the northeast of the country neighbouring the Gulf of Venezuela and lake Maracaibo. The coastline of Venezuela is 4000 km long in the north that lies on the Caribbean Sea and the Atlantic Ocean. Major sectors of the economy- the oil extraction, tourism and fishing are largely concentrated in this coastal area. Coastal topography is very low and flat.

Venezuelan is located on the tropics. The climate is hot and humid with a moderate rainfall. Climate shows a significant variation in different regions depending, mainly, on elevation. Lower the elevation, higher is the temperature. The lowest temperature found below 8 ^{0} C annual average at over 3000 meters elevation. Temperature ranges from 9^{0} C to 11^{0} C between 2000 and 2500 meter elevation and 12^{0} C to 25^{0} C between 800 and 2000 meter elevation and 26^{0} C to 28 ^{0} C in the coast. The country has a specified rainy season from May to November; however, average rainfall varies with locations. In the lowlands, highest rainfall occurred in the Orinoco Basin. In the mountain rainfall also varies depending on the direction of winds and orientation of the slopes.

2.5.2 Projected Scenarios of Climate Change in Venezuela

1. Changes in Temperature

Venezuela is the hottest country in the South America (Hulme and Sheard 1999) and the prediction shows that there will be a modest rise in temperature. The average temperature for the country will increase by 1-2 ^{0} C by 2060 (World Bank, 2008c). The available climate change models for Venezuela namely PCM- applied by the National Centre for Atmospheric Research, USA; CSIRO- applied by the Australia's Commonwealth Scientific and Industrial Research Organization; and CGCM2- adopted by the Canadian Centre for Climate Modelling and Analysis, Canada also gives the similar results. Though the three Models vary in predicting the future temperature changes, the average gives the clear estimation that the temperature change will increase by 4.5 ^{0} C by 2100 from the base year of 2000 (Seo, 2005). Venezuela falls under the Central American region and, IPCC estimates that the possible temperature increase for this region will be following:

Table 13: Projected Temperature Changes for Venezuela

Seasons	2020	2050	2080
Dry Season	+0.4 to +1.1	+1.0 to +3.0	+1.0 to +5.0
Wet Season	+0.5 to +1.7	+1.0 to +4.0	+1.3 to +6.6

Source: IPCC, 2007

Especially for the Andes region IPCC calculated the average annual temperature increase by just over 1^{0} C in the B1 scenario while by over 3^{0} C in the A2 scenario (Hulme and Sheard, 1999).

2. Changes in Precipitation

Generally, precipitation for Venezuela will be decreased though for some mountainous region it may increase. Studies show that there will be a reduction of precipitation by 20% in 2060 than that of 1990. Reduction of precipitation will be robust particularly in the southern state of Bolivar and in the northern side of Orinoco River (Hulme and Sheard, 1999). The PCM models predict that Venezuela will not have a dramatic change in its precipitation as it will get wetter through 2080 and then returns to its 2000 level (Seo, 2005). IPCC estimates ranges of change in precipitation of Central America that also more signalling to larger decrease possibility rather than the increase. The findings follow:

Table 14: Projected Change in Precipitation in Venezuela

Seasons	**2020**	**2050**	**2080**
Dry Season	−7 to +7	−12 to +5	−20 to +8
Wet Season	−10 to +4	−15 to +3	−30 to +5

Source: IPCC, 2007

For the Andes region IPCC calculated that the Venezuelan part of Andes will be dryer while the other parts will be wetter (Hulme and Sheard, 1999).

3. Sea Level Rise

IPCC calculated that for Venezuela, a possible sea level rise would be 38- 104 cm by 2080 depending on the various scenarios (IPCC, 2007).

2.5.3 Physical Impacts of Climate Change

1. Droughts and Floods

Given the scenarios of temperature rise and a reduction of precipitation, the average availability of water will be reduced. the intensification of dryness will contribute to an extension of desertification from 39% of total area to 47% by 2060 (World Bank, 2008c). Though the precipitation is predicted to be decreasing, the melting of glaciers from the Andes in the other country's territory can contribute to an increase in the water flow in Venezuelan river system and can cause flash floods in some part of the country.

2. Coastal Inundation and Erosion

As the coastline in Venezuela is very low lying, the rise of the sea level between 2 and 10 cm per decade (as suggested by IPCC) will be devastating in terms of the coastal erosion and inundation. Thousands of hectares of land can go under permanent inundation due to rise in the sea level (Hulme and Sheard, 1999). The two important islands and tourist spots named *Isla de Aves* and the *Isla Margarita* are in immediate threat of rise in water level in the Caribbean Sea (Faria, 2005).

2.5.4 Need for Adaptation

Further to the analysis of impacts, a summery of adaptation need for Venezuela is given presented below:

Table 15: Adaptation Need for Venezuela

Challenges/ Issues	**Climatic reasons (Why?)**	**extend**
Agriculture and food Security	▪ Decrease precipitation ▪ Desertification and extended drought	Due to decreased precipitations: yield will decrease by 4.4% for corn, 13.4% for caraota and 4.4% for rice by 2020.
Fisheries	▪ Increased inundation and erosion in the coast.	-
Tourism and biodiversity	▪ Islands are in the threat of extinction that hosts a diverse species. For Venezuela there is risk of Orinoco crocodile to be extricated.	
Human Health	▪ temperature rise will increase parasites	

	like mosquitoes and will contribute to malaria, dengue etc.

Source: Author's own compilation, 2009

2.5.5 Options for Adaptation

In line with the identified impacts and threats the available adaptation measures are summarised below:

Table 16: Options for adaptation for Venezuela

Adaptation measures	**Why**
1. Increase irrigation and drainage	▪ to make more land available for agriculture
2. Adaptive technology	
- -saline and drought tolerant crop varieties	
-alternative cropping pattern	▪ for agriculture and food
- non-traditional fisheries	▪ for fisheries
3. construction of resilience infrastructure to climate change	▪ to save the infrastructure from coastal inundation
4. Awareness building	
5. Research and Institution building	

Source: Author's own compilation, 2009

CHAPTER THREE: A SYNTHESIS OF ADAPTATION OPTIONS

3.1 Key Findings

1. The five developing country case studies from five different regions offer some very important findings that at times facilitate to synthesize those findings into a common stance under the tag of developing country while sometimes undermine the attempts to categorize those under such a single entity.

2. Selected countries are primarily developing countries though there is a significant difference in their development levels. In the HDI index 2007 (UNDP, 2007) most of the selected countries rank below the first 100 positions with the only exception of Venezuela that secured the position at 74 thanks to its very high oil revenues. In general, the countries share the similar incidence of poverty, physical infrastructure and living conditions in the low laying floodplain areas. The most important thing is that every country shares similar types of stresses resulting from climate change. Increased frequency of floods and droughts are very common for all these countries where the majority of the people live on agriculture, fisheries and related activities. Cyclones, hurricanes and typhoons are also becoming very intense and frequent in most of the developing countries. Coastal areas in the countries are particularly vulnerable to these storms. As the major economic activities and a high percentage of population concentrated on the coastal floodplains, the people are becoming increasingly exposed to climatic vulnerability and their livelihood losses. Other stresses are related to the permanent inundation, salinity intrusion and coastal and

riverbank erosions. These impacts on coastal areas pose great threats to the biodiversity and ecosystem, infrastructure, agriculture and fisheries sectors- on what millions of the poor people depend for their livelihoods. Particularly, tourism in Latin America and the Caribbean is exposed to threat from the coastal erosion, inundation and salinity.

3. The available adaptation options for such stresses in the developing countries in general falls under four different categories: 1. hardware-based adaptation mechanism- making dams, dredging of rivers, making infrastructure resistant of coastal flooding and cyclones, drinking water projects etc.; 2. adaptive technologies- introduction of new verities of seeds tolerant of droughts and salinity, alternative cropping system to cope with the changes of precipitation, changes in land use pattern, tree plantation etc.; 3. community involvement- sharing the community knowledge on stresses and involving the community to the adaptation process in an effective way, the community and social capital based early warning system may be an area for adaptation to climate change in poor countries; and 4. the research and institution building- the institutions in the developing countries are not in a position to tackle such a new phenomenon that needs a rebuilding of institutions that work for combating climate change, specialised research on agriculture and other adaptive options are also priorities and most importantly, institutions like insurance can be adopted for the loss of crops, settlements and livelihoods.

Table 17: Synthesis of Adaptation Measures

Rank	Adaptation measures	B.desh	V.nam	M.bique	Haiti	V.zuela
1.	Saline, drought and flood tolerant crop varieties	√	√	√	√	√
1.	Alternative cropping pattern	√	√	√	√	√
1.	Non-traditional fisheries	√	√	√	√	√

1.	Awareness building	√	√	√	√	√
2.	Resilient infrastructure	√		√	√	√
3.	Disaster tolerant settlement	√		√	√	
3.	Improvement of drainage system	√		√		√
3.	Afforestation	√	√		√	
4.	Crop insurance	√		√		
4.	Land use policies/planning		√	√		
4.	Water management		√	√		
4.	Improved Irrigation		√			√
4.	Early warning system	√	√			
5.	Riverbank protection	√				
5.	Zoning in coastal areas		√			
5	Community fire management		√			

Source: Author's own compilation, 2009

4. The synthesis of options for adaptation revealed that the need for adaptive technology has gotten the 1st ranking as every country's agriculture, fisheries and other livelihood options for vast population are exposed to increased threat. The saline, drought and flood resilient crop varieties become the topmost adaptation agenda for the developing country that need huge funding for research and development. Awareness building at the community level also got the highest ranking shows that the public awareness at the local level is the key for successful adaptation. Building of resilient infrastructure became second adaptive options while improved drainage system and afforestation comes as the third adaptive priorities (see table 17).

5. The country studies offered very definite choices for adaptation to climate change for developing countries in general while also signals very different patterns of calamities that would not be wise to categorize under the tag of developing countries. The study found that there is a visible regional distribution of patterns, intensity and frequency

of calamities resulting from climate changes. Climate change related stresses have a very strict geographical character rather than a developmental character though development level matters in assessing country's ability to adapt climate change stresses. For example the Himalayan region has a very distinct geomorphological character that does not match with the geomorphological condition of other regions, say for Caribbean. In this way the synthesis of the country studies concludes with two very important findings:

a. There are similar adaptation need to climate change for the developing countries and,

b. There are regional patterns of concerns for stresses on the top of developmental status of the countries

CHAPTER FOUR: HOW EFFECTIVE IS THE INTERNATIONAL REGIME FOR CLIMATE CHANGE ADAPTATION FOR DEVELOPING COUNTRIES?

4.1 Brief Overview of Climate Change Adaptation under UNFCCC

UNFCCC advised the adaptation in its convention article 4.1, 4.8 and 4.9. By date, the emphasis in given to the process of national communications from the developing countries on needs for adaptation, NAPA[10]s from the LDCs, technology transfer, research and training and the finance guidance of GEF (Global Environmental Facility) (JLGRC, 2007). The UNFCCC commits on assisting adaptation process in the developing countries through collecting financial contribution from the developed ones supervised by the GEF which is accountable to the COP, the highest body at the UNFCCC decides on climate change policies, programme priorities and funding on projects based on the advice from SBI (UNFCCC, 1992).

In brief, adaptation to climate change under UNFCCC is managed by three distinct instruments: The Nairobi Work Programme, the five year programme started in 2005, aimed to assist the parties (the states) to understand their vulnerability to the impacts of climate and also identifying their need for adaptation; Subsidiary Body of Implementation (SBI) gives advice to the Conference of Party (COP), the highest body in UNFCCC on the implementation of both the adaptation and mitigation measures; and National Adaptation Programme of Actions (NAPAs) provide the information to assess and prioritize the urgent and immediate needs for adaptation of least developed countries (Pilifosova, 2000).

[10] National Adaptation Programme of Action

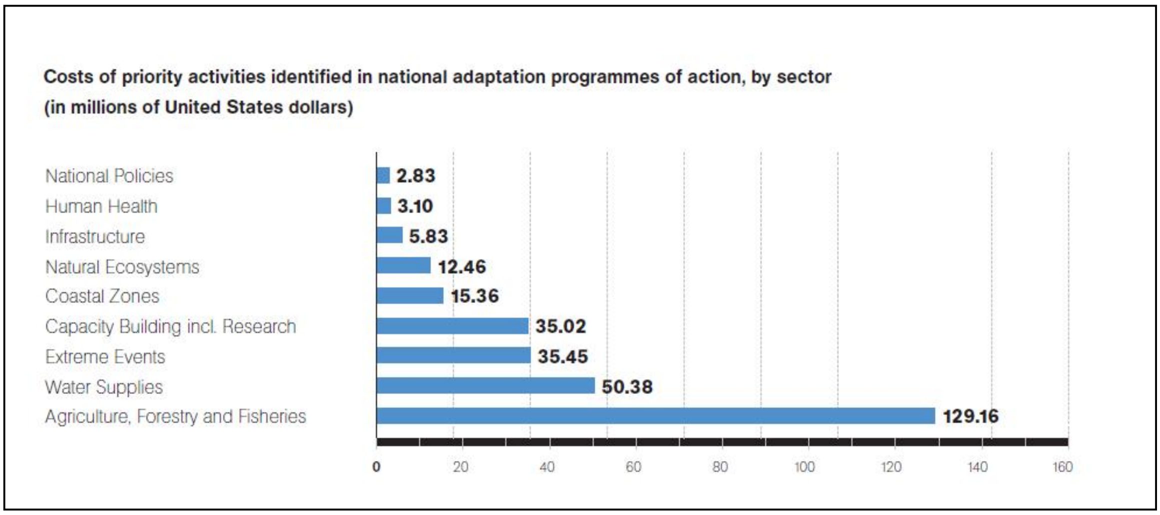
It was felt at the UNFCCC that the developing countries need financial and technical support to assess their vulnerability to climate change and to prepare their own communications to the UNFCCC. GEF fully funds the preparation of national communications and facilitates the adaptation initiatives. Considering the special needs for the LDCs, the UNFCCC adopted a work programme under which it promotes the countries to prepare their National Adaptation Programmes of Action (NAPAs). The Least Developed Countries Expert Group (LEG) provides advice on preparing and implementing NAPAs (UNDP, 2008). NAPA serves as the blue print for the adaptation measure to be taken at the county level in LDCs. Each country prepares its own NAPA that also includes the country's priority needs for adaptation. UNFCCC then examines the proposals attested in NAPA and granted the projects and associated supports for the country.

Nairobi Work Programme (NWP) is initiated in 2005 aimed to fulfil twine objectives: first, to assist the countries to improve their understanding on vulnerability, impacts and adaptation and second, to assist countries to make informed decision on climate change adaptation measures considering the scientific projections and socio-economic realities. The latest development on climate change adaptation is the Bali Action Plan that envisaged an innovative way to mobilise financial resources, investments and technology transfer. The action plan introduces the CDM[11] levy to raise funds for adaptation, first of this kind. It also advised a financial arrangement under 'Adaptive Fund Board' that will manage all funding while GEF will provide secretarial support to the board (Bals, 2009).

[11] Clean Development Mechanism

4.2 Priority Areas for Adaptation and Implementation Measures under UNFCCC

The priority areas of action are selected based on the National Adaptation Programme of Actions (NAPAs) and National communications from the countries to the UNFCCC. The whole processes of preparation of such national documents are supported both financially and technically by the UNFCCC. In that sense it is very difficult to ascertain whether the policies and measures are reflecting the realities on the ground. Major studies on adaptation assessments, priorities and programmes are financed by the GEF and the documents consulted for this research also largely comes from the mainstream UNFCCC and related literature. The identified options for the developing countries in this research, by design comply with the programmes and priorities of the UNFCCC as both shares the same studies. However, the available information shows that the UNFCCC is still largely facilitating the country level studies on adaptation needs and the actual adaptation programme on the ground is not that visible yet. The following graph shows the UNFCCC prioritized nine sectors and estimated costs.



Source: adopted from UNFCCC, 2008

It shows that the national policies still gets the highest priorities when the countries already paying the costs of climate change. There is an urgent need for developing the adaptive technologies on agriculture, fisheries and livestocks; investing on the disaster resilient infrastructures; building awareness of the population in threat through community-based early warning system etc. that are not still the priority at the UNFCCC partly due to the its focus on national level assessments and partly due to its financial inability to fast-track the adaptive measures. In that way, it can be said that the UNFCCC follows a process of identifying the needs at the country level that incorporates the country expertise with UNFCCC expertise, seems to be very effective (as we cannot judge it), still the priorities at the global level rests on preparing the country studies that should be move forward to the practical actions as the adaptation measures are urgent in many parts of the world, especially in the developing countries.

Why the priorities are still on less-expensive studies rather than of the actions, can be answered easily when one sees the current funding situation at the UNFCCC level.

The UNFCCC funding for the implementation of the adaptation measures are very crucial as it is the responsibility of UNFCCC to mobilize funds for selected projects under the article 4 of the convention (UNFCCC, 1992). There are four funds set-up under the UNFCCC and Kyoto protocol. Three funds namely the Trust Fund's Strategic Priority on Adaptation (SPA), the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF) have been set-up under the UNFCCC's Global Environment Facility (GEF). The fourth fund called Adaptation Fund (AF) is established under Kyoto Protocol.

Table 18: Estimated costs for adaptation by different organizations

Organization	**Estimated Costs**
World Bank	US$ 1040 billion (annually)
UNFCCC	US$ 28-67 billion (in 2030)
UNDP	US$ 86 billion (by 2015)

Oxfam International	US$ 50 billion (annually)
Christian Aid	US$ 100 billion (annually)

Sources: Flåm and Skjærseth (2008)

Current disbursement of the funding is very meagre comparing to the estimated costs by any of the organizations above while the developed countries are legally bound under Article 4 of the convention to provide the adaptation finance for the least developed countries and the developing countries (Flåm and Skjærseth 2008).

Table 19: Current appropriation of funds for Adaptation under UNFCCC

Fund	**Pledged (Million US$)**	**Received (Million US$)**	**Disbursed (Million US$)**
SPA	50	28	14.8
LDCF	163.3	52.1	12
SCCF	70	53.3	6
AF	-	-	-
Total	283.3	133.4	32.8

Sources: Flåm and Skjærseth (2008)

Until the end of 2007, only 133.4 million US dollar is received under the different funds of UNFCC and disbursed only a meagre amount of 32.8 million US dollar that comprises a tiny fraction of the needed billions of US dollar even by the most conservative estimations.

Moreover, the analysts suggest that the delay of the programme implementation is not only caused by the shortage of funding but also by the institutional difficulties lying between the recipient country and fund management authorities (Bapna and Mcgray 2008).

4.3 The Lack of Regional Treatment

The adaptation measures are prioritized according to the country NAPAs and the national communications. The study found that there is a very important regional geographical distribution of climate change hazards. There is no attempt in UNFCCC to divide the world into geomorphological hazard maps and then initiates the regional cooperation for adapting such hazards. There is an extreme need for geographical co-operation for maintaining regional forests like Amazon, mountains like Himalayans and most importantly the river systems that cross over a number of countries before falling into the sea. Country-wise adaptation is prone to fail due to regional non co-operations and the dependency on other territories. The multiple nature of the stress is very much absent in the current understanding of UNFCCC. One of the most effective ways could be the setting up of regional hub for different climatic zones that will bind the related countries to share with the meteorological information and should offer cooperative project proposal that will be implemented under the guidance of UNFCCC.

4.4 Institutions and Adaptation

Over reliance of environment related experts in the every organization under the UNFCCC is another problem for understanding the stresses. The IPCC reports are the basis of climate change actions in the UNFCCC. IPCC is overwhelmed with the environmental experts even for the Working Group II that works on Adaptation. Country studies done for this research revealed that the UNFCCC focal point for each and every country is department of environment. IPCC also founded by the joint collaboration of the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). It is increasingly felt that the climate change adaptation is a multidisciplinary approach. The efficient adaptation mechanism needs to include experts from social sciences to understand the community needs and adaptive capacities and the local level.

CHAPTER FIVE: CONCLUSION

In a nutshell, the study evaluate that the international policy making for adaptation measures are primarily country specific. Country level studies are the basis for dealing with the adaptation agenda in the international level. In that context, the priorities at the national level are largely reflected in the international policy regime. However, shortage in finance for adaptation makes UNFCCC nearly ineffective in taking the necessary measures on adaptation. Whatever the priorities in programmes are, become irrelevant in the backdrop of financial shortage as majority of those programme cannot be implemented. In that sense, adaptation under UNFCCC is still largely ineffective. UNFCCC's focus on political boundary of states and regions is also proved to be flawed while the focus should be on geomorphological climatic zones. The institutional problem of coordination and lack of expertise due to over reliance on environment related experts is also a major reason for not appropriating the full potential of UNFCCC. All the country adaptation programmes are identified, researched, communicated and implemented by the ministry of environment and related functionaries. The focal points for maintaining communication to the UNFCCC, at the country level, is the department of environment. The nature of stress originated from climate change not entirely environmental and there is a dire need to change the perception at the international level.

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