

# MAINSTREAMING ADAPTATION TO CLIMATE CHANGE IN LEAST DEVELOPED COUNTRIES (LDCS)

Working Paper 1: Country by Country Vulnerability  
to Climate Change **Saleemul Huq, Hannah Reid  
and Laurel Murray** April 2003



The International Institute for Environment and Development **CLIMATE CHANGE PROGRAMME** was established in 2001. The programme's goal is to enhance understanding of the linkages between sustainable development and climate change. Priority themes for the programme include: enhancing adaptation capacity in developing countries; climate change and sustainable livelihoods linkages in developing countries; capacity strengthening in developing countries; information dissemination; equity and; enhancing opportunities for developing countries to take advantage of opportunities offered for carbon trading (including CDM).

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## **Preface**

This report provides information on the Least Developed Countries (LDCs) in relation to their population size, reliance on certain sectors, vulnerabilities to climate change, and current or recommended strategies for climate change adaptation. It is hoped that this report will act as a resource to governments, NGOs, researchers and practitioners working with LDCs in relation to their adaptation to climate change. Most information has been obtained from United Nations Conference on Trade and Development (UNCTAD) data, the Intergovernmental Panel on Climate Change (IPCC) and National Communications (NC) Strategies. The varying length of each country report reflects the difference in levels of information available for each country from these documents.

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### Least Developed Countries Summary Table

Name	Population (million)	GNP per capita (US\$)	% share of GNP in agriculture, forestry, fisheries	% share of GNP in industry	% share of GNP in services	Gross Domestic Investment	Main Exports (% of total exports)
Afghanistan	21.4	-	-	-	-	-	Dried fruits and nuts (51.3)
Angola	12.1	380	12.3	51.5	36.3	20.2	Petroleum (70.9)
Bangladesh	124.8	350	22.2	27.9	49.9	22.2	Garments (52.3)
Benin	5.8	380	38.6	13.5	47.9	17.1	Cotton yarn (38.9)
Bhutan	0.6	470	38.2	36.5	25.4	47.3	Electricity (24.9)
Burkina Faso	11.3	240	33.3	27.2	39.5	28.6	Raw Cotton (36)
Burundi	6.5	140	54.2	16.4	29.5	9.0	Coffee (73.4)
Cambodia	10.7	260	50.6	14.8	34.6	15.0	Saw Timber (25.3)
Cape Verde	0.4	1200	12.2	19.1	68.7	40.2	Air Transport Services (34.6)
Central African Republic	3.5	300	52.6	18.6	28.8	13.5	Diamonds (42.2)
Chad	7.3	230	39.8	14.3	45.9	15.0	Cotton Lint (48.9)
Comoros	0.7	370	38.7	12.8	48.5	19.8	Travel (51.7)
Democratic Republic of the Congo	49.1	110	58.0	16.9	25.3	8.1	Diamonds (17.2)
Djibouti	0.6	-	3.7	20.6	75.9	9.5	Gov Services to Expatriates (57.2)
Equatorial Guinea	0.4	1110	21.8	66.4	11.8	84.6	Petroleum Products (43.4)
Eritrea	3.6	200	9.3	29.6	61.2	41.0	Port Services (76.5)
Ethiopia	59.7	100	49.8	6.7	43.5	18.2	Coffee (36.1)
Gambia	1.2	340	27.4	13.7	58.9	18.4	Travel (58.8)
Guinea	7.3	530	22.4	35.4	42.1	21.1	Bauxite and Alumina (51.6)
Guinea-Bissau	2.2	160	62.4	12.7	24.9	11.3	Cashew Nuts (74)
Haiti	8.0	410	30.4	20.1	49.6	10.7	Clothing (29.7)
Kiribati	0.9	1170	20.7	6.1	73.2	-	License fees/royalties (58.5)
Lao People's Democratic Republic	5.2	320	52.6	22.0	25.4	24.9	Wood Products (27.3)
Lesotho	2.1	570	11.5	42.0	46.5	48.6	Clothing (42.8)

Liberia	2.7	-	-	-	-	-	Iron ore (55.1)
Madagascar	15.1	260	30.6	13.6	55.8	13.3	Coffee (11.7)
Malawi	10.4	210	35.9	17.8	46.4	13.7	Tobacco (59.9)
Maldives	0.3	1130	16.4	-	-	-	Travel (71)
Mali	10.7	250	46.9	17.5	35.6	20.9	Cotton products (48.4)
Mauritania	2.5	410	24.8	29.5	45.7	21.0	Iron ore (47.8)
Mozambique	18.9	210	34.3	20.8	44.8	20.4	Business services (42.7)
Myanmar	44.5	-	53.2	9.0	37.8	11.7	Food and live animals (34.6)
Nepal	22.9	210	40.5	22.2	37.3	21.7	Basic Manufactures (38.9)
Niger	10.1	200	41.4	17.0	41.7	10.4	Uranium (39.4)
Rwanda	6.6	230	47.4	21.2	31.4	15.7	Coffee (43.2)
Samoa	0.2	1070	-	-	-	-	Travel (47.4)
Sao Tome and Principe	0.1	270	21.3	16.7	62.0	41.3	Cocoa (37.5)
Senegal	9.0	520	17.4	24.1	58.5	19.6	Fish (19.8)
Sierra Leone	4.6	140	44.2	23.9	32.0	8.1	Travel (45.3)
Solomon Islands	0.4	760	-	-	-	-	Timber products (42.7)
Somalia	9.2	-	-	-	-	-	Livestock (44.3)
Sudan	28.3	290	39.3	18.2	42.6	-	Sesame seeds (19.7)
Togo	4.4	330	42.1	21.1	36.8	14.2	Cotton products (30.9)
Tuvalu	11.0	-	-	-	-	-	Travel (29.5)
Uganda	20.6	310	44.6	17.6	37.8	15.1	Coffee (53.7)
United Republic of Tanzania	32.1	220	45.7	14.9	39.4	15.0	Travel (34.9)
Vanuatu	0.2	1260	24.7	12.2	63.2	-	Travel (33.9)
Yemen	16.9	280	17.6	48.8	33.7	21.5	Petroleum (83.7)
Zambia	8.8	330	17.3	26.4	56.3	14.3	Copper (70.6)

Data from the UNFCCC at <http://r0.unctad.org/lcd>





## AFRICA

### Burkina Faso



#### **Statistics**

Population	11.3 million
GNP per capita	US \$240

#### **Percentage share of GNP**

Agriculture and livestock	33.3%
Industry	27.2%
Services	39.5%
Gross Domestic Investment	28.6%
Main Export	Raw cotton (36% of total export)

#### **Vulnerabilities to Climate Change**

- The Mossi in Burkina Faso have achieved a doubling of tree densities in certain semi-arid areas with *Butyrospermum parkii*.

Data from UNCTAD and IPCC.

### Democratic Republic of the Congo



#### **Statistics**

Population	49.1 million
GNP per capita	US \$110

#### **Percentage share of GNP**

Agriculture and livestock	58%
Industry	16.9%
Services	25.3%
Gross Domestic Investment	8.1%

Main Export

Diamonds (17.2% of total export)

**Vulnerabilities to Climate Change**

“Climate change models to date indicate minimal changes in the hydrology of the Congo basin, whereas other basins have significant vulnerability to climate change. A regional project to develop the hydropower potential of the Congo basin could significantly increase the energy security of the region without resort to GHG-emitting, coal-driven thermal power plants.” (IPCC p.516)

Data from UNCTAD and IPCC.

**Djibouti**



**Statistics**

Population 0.6 million  
GNP per capita unknown

**Percentage share of GNP**

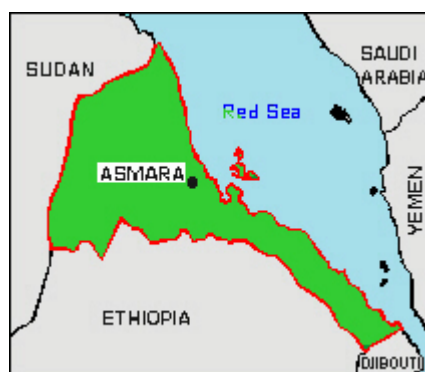
Agriculture and livestock 3.7%  
Industry 20.6%  
Services 75.9%  
Gross Domestic Investment 9.5%  
Main Export Government services to expatriates (57.2% of total export)

**Vulnerabilities to Climate Change**

- Increase in vector-borne diseases like dengue fever.

Data from UNCTAD and IPCC.

## Eritrea



### **Statistics**

Population	3.6 million
GNP per capita	US \$200

### **Percentage share of GNP**

Agriculture and livestock	9.3%
Industry	29.6%
Services	61.2%
Gross Domestic Investment	41.0%
Main Export	Port services (76.5% of total export)

- Population concentrated heavily in the cooler central highlands, with 80% employed in agriculture, mostly subsistence living.
- Varied climate ranging from the humid central highlands to arid lowlands and semi-desert, with precipitation varying from 1100 mm to 200 mm respectively.
- The NC proposed that Eritrea could increase its fish catch from 13,000 to 70,000 tones per year, and would still be sustainable in their opinion.
- The government also believes the mining sector could be further developed.

### **Vulnerabilities to Climate Change**

- The NC used the GCM and UK89 models for their assessment of vulnerability.
- Rainfall is a limiting factor in agriculture, so with precipitation becoming more varied, agricultural production may suffer.
- According to the climate change models, the mean annual temperature for Eritrea is expected to rise at the equilibrium level of 2 x CO<sub>2</sub>. There will be an increase of temperature and the range between the monthly mean will vary from 29-37°C, 28-37°C and 18-26°C in the coastal plains, the western lowland and in the central highlands respectively. The increase of temperature due to doubling of GHG concentration across the country is expected to rise by 4.1°C, well within the IPCC's globally predicted range, i.e. 1.5 to 4.4°C for effective doubling of CO<sub>2</sub> over the next century. On the other hand precipitation is expected to vary by a ratio of 0.1 to 0.15.

### Agriculture

- It is believed that agriculture will be the most heavily impacted by climate change.

“Owing to its ecological diversity, Eritrea produces a wide-range of cereals, vegetables, pulses, fiber crops, etc. Subsistence farmers in the highlands, *inter alia*, grow sorghum, millets, barley, wheat, legumes and taff (*Eragrostis teff*), while in the lowlands the main crops grown are sorghum and millets. Sorghum is the main crop in the country and accounts for about 46% of the total cereal production in the country. Next to sorghum are pearl millet and barley, accounting for about 16% and 15% of the total production, respectively. Eritrea is also

famous for the production of tropical fruits like lemon, orange and bananas, which are also widely grown in the country.” (NC p.43)

“It is commonly observed that the frequency of the variability of these events has been increasing during the last forty years or so, and consequentially agricultural production has been decreasing from time to time. Drought has been hitting the country every 5-7 years in the past, with adverse effects on crop production, and between 1972 and 1987 there were three catastrophic droughts.” (NC p.44)

- In the NC, sorghum (grown in the drier lowlands) and barley (grown in the cool highlands) were used to assess climate change vulnerability...
- According to the GCMs simulation, the growth duration and biological yield of barley is projected to decrease both under rain fed and irrigated conditions.
- The GCM also predicted an adverse water balance under climate change with seasonal rainfall (evapo-transpiration and extractable water are projected to decrease and runoff increases). Also, the models predicted that nitrogen leaching would increase while nitrogen uptake and soil inorganic nitrogen would decrease.
- Increased temperatures will cause a decrease in total biomass since the growing season will be shortened and because of moisture and nutrient (nitrogen) stress.

“It may thus be inferred that the full effects of climate change on barley production will exceed the immediate benefits of increased atmospheric CO<sub>2</sub> concentrations.” (NC p.46)

- In contrast, the GCM scenarios invariably predicted increase in the length of the growing period of the sorghum crop, which results in the increase of biological yield of sorghum both under rain fed and irrigated conditions.

“The GCM further predicted rainfall and extractable water to decrease; whereas soil inorganic nitrogen and nitrogen uptake to increase with a simultaneous decrease in nitrogen leaching. Surprisingly, the growth duration and biological yield of sorghum are projected to increase in the wake of adverse water balance - a phenomenon inconceivable under normal climatic conditions. Thus it has to be inferred that the positive effects of atmospheric CO<sub>2</sub> concentration will exceed the adverse effects of climate change. In addition, the rise in temperature under climate change may not have negative impact on the growth of sorghum as opposed to that of barley.” (NC p.46)

- However, the NC did not mention that since the vast majority of the population live in the humid highlands, the impact on those crops, like barley, are more important than the lowland crops.

#### Water Resources

- Eritrea lies in the Sahelian belt, which experiences frequent droughts.

“Rainfall is erratic and torrential and quickly forms heavy floods with little chance of penetrating into the ground. Perennial streams hardly exist and there are no lakes, and rivers. Setit is the only perennial river. The potential of underground water resources is still not clearly studied and documented. Moreover, meteorological and hydrological information, which is critical for any water resource development activity, is at its early stage of development.” (NC p.50)

“The Mereb-Gash basin was selected for the vulnerability assessment of the water sector, mainly because of the availability of discharge data in this basin and more importantly this basin probably has the highest potential for agricultural activities, both for rain-fed and irrigated agriculture, than the other river basins.” (NC p.51)

- Overall, climate change is predicted to harm the already scarce water resources in the country.

### Forestry

- The forest area of the country has been reduced from 30% in 20<sup>th</sup> century to about 2.4% now.

“The conversion of forests and woodlands into agriculture, fire wood collection and overgrazing also exacerbated the situation. El Nino related drought of early 1970s, 1982-85, and in the 1990s have also caused massive plant losses.” (NC p.57)

“Deforestation on steep lands has increased the sediment loads of rivers, reservoirs and canals. Exposed soils, particularly following mechanical clearing, are subject to erosion, compaction and crusting.” (NC p.57)

“Despite various efforts at conservation, the destruction of this natural vegetation continues unabated. Alarmed by such precarious state of the environment, the Government of the State of Eritrea introduced a number of control measures. For example, law forbids cutting live trees, hunting of wild animals, and charcoal making. In parallel, the government has mobilized rural population and students to construct hillside terraces and plant seedlings. It also encouraged area closures of degraded hills and woodlands for natural regeneration. Planting trees along roads and homestead is also widely encouraged.” (NC p.57-8)

- There is a predicted shift in forest distribution attributed to either future increase or decrease in precipitation and an increase in ambient temperature.

“Under climate change, the country would have more diverse bio-climatic zones. Tropical thorn (grasslands/wooded grasslands) woodland would dominate a large portion of the central highlands, the eastern and western escarpment, and central part of the western lowland. The southern zone of the central highlands, southwestern lowlands and higher altitudes of the eastern lowlands would be dominated by the tropical very dry forest (open and closed/medium closed woodlands). The northern portion of the country would be dominated by tropical desert scrub (bush lands/scrublands). There would be also pockets of other types of bio-climatic zones...” (NC p.59)

- However, the results generated by these models should be taken cautiously. “The model predictions are almost opposite the present forest cover and this has resulted in the expression of serious reservations about these models by concerned experts.” (NC p.60)

### Coastal zone

- According to the UK89 model, the average increase of temperature, due to doubling of GHG concentrations (2 x CO<sub>2</sub> scenario) will be about 4.1°C, causing a 0.5 to 1 m rise in sea level.
- A 0.5 m increase of sea level rise would result in the submerging of infrastructure and other valuable economic installations.
- For example, sea level rise could cause an economic loss of about US \$242,750,000 in the Edaga area and US \$14,080,000 in the Tewalet area.
- Possible disruption to marine ecosystems, namely fish stocks and coral productivity.

### Human Health

- Diseases in the country include diarrhoea, malaria, acute respiratory infections (ARI), tuberculosis, eye infections, and skin infections.

- The main causes of ill health include poor environmental sanitation, inadequate and unsafe water supply and poor housing conditions, which might also include the effect of climate change.

“The climate change scenario has revealed that there would be a significant increase in temperature and slight increase in rainfall in Eritrea. These environmental conditions may favour the development of Anopheles vectors and hence would have profound effect on the incidence and prevalence of malaria.” (NC p.69)

### ***Current or Recommended Strategies for Climate Change Adaptation***

#### ***Agricultural Sector***

- A policy framework to combat climate change-induced problems coupled with appropriate institutions to translate policy objectives into concrete action;
- Protection and sustainable use of natural resource base on which agriculture depends;
- Improvement of existing crops, technologies and traditional knowledge systems;
- Education and mobilization of the public for effective participation in the fight against the potential negative impacts of climate change;
- Construction of a comprehensive information system along with an early warning system;
- Linkage with regional and international networks involved in climate change studies; and
- Setting up a co-ordination mechanism to enable stakeholders i.e. policy makers, development planners, scientists, rural communities and farmers to participate constructively in the efforts to adapt to climate change.
- The construction of dams and check-dams has been one of the major engagements of the Government since independence in 1991.” (NC p.48) For instance, between 1992 and 1999, more than 75 concrete and earthen dams were built and more than 1000 km long check-dams. Also, the government hopes to undertake assessment studies of the underground water potential of Eritrea, including water irrigation potential of the major river basins, including that of Gash-Barka River basin.
- Establish and strengthen a national meteorological and hydrological information system.
- Develop a national disaster management strategy to mitigate the adverse impacts of periodic droughts. This has to do with early warning system that has to be coordinated by concerned institutions, such as the Ministry of Land Water and Environment, the Ministry of Agriculture, the Ministry of Transport and Communications, the Ministry of Fisheries, etc.
- Cost effective water management policies should be put in place, including a pricing policy.

“Moreover a national water law must be put in place to regulate and manage the sustainable use of water resources.” (NC p.49)

#### ***Forestry Sector***

- The deforested sites should be rehabilitated and improved through afforestation, enrichment planting, and area closure to realize economic and social benefits from the forests. Selecting more suitable tree species.
- Integration of multipurpose tree and shrub species in the agricultural land to provide fuel wood and poles as well as for land stabilization, soil improvement, shelter and silvipasture.
- Re-establishment of wild life habitats in selected areas such as Buri Peninsula and Hawakil Bay for the conservation of terrestrial wild life in those areas.
- Design of fuel wood collection management practice within the productive capacity limits of the forests and woodlands.

- Introduce comprehensive rehabilitation and protection plans for the Mount Bizen and Semienawi Bahri forest area to meet the fuel wood and fodder requirements of rural and urban communities and to reduce silt down stream.
- Provide incentives to promote community involvement in forestry conservation programs. Moreover, encourage private reforestation schemes and ensure that all trees planted are the property of the individuals who planted and cared them, without prejudice to any law introduced from time to time regulating or limiting of felling or destruction of privately owned trees.
- Replacement of thatched roofs for traditional houses known as *Hudmo* and *Agudo* by corrugated iron sheets to reduce the consumption of construction poles. It has been reported that at least 100 live trees have to be cut to construct a traditional house (*Hudmo*) in the central highlands.
- Introduce proper land use planning. Demarcate and designate forest areas and discourage other types of land use. To overcome land use changes proper resource management plan should be drawn and an overall land use map of the country should be prepared.
- Encourage school wood-lot programs and wood-burning stove improvement in the country.
- Introduction of a national reforestation schemes to create a well-managed fuel wood plantation for each village, the reforestation work to be carried out by the villagers themselves.
- Delineate certain forest areas within the Green Belt for the conservation of forest genetic resources, encouraging natural regeneration through closure etc.
- Reduction of wood energy demand through greater efficiency of wood energy conversion and utilization or substitution of wood fuels by alternative energy sources.
- In the highlands, there is scarcity of forage and fodder because of deforestation and degradation of grazing areas. The farmers will have to adapt to a lower number of livestock to cope up with the carrying capacity of the pastures or make provision for stall-feeding. Some of them may even have to give up this profession to avoid depletion of the pasture and to prevent land degradation.

#### Coastal Areas

- The construction of walls (steel or concrete) along the entire length of the coastline, up to 25 km to the hinterland where economic activities are being carried out, would cost in the range of US \$50-500 million, depending on the type of construction materials chosen. Such walls may reach up to 2 m in height. This appears worth constructing given the potential damage of sea level rise on the economic activities of coastal areas.
- The development of an integrated coastal zone management plan (ICZMP) needs to be considered, taking into account short and long-range concerns of climate change. The coastal zone management plan will have to address, *inter alia*, coastal erosion, pollution, and habitat destruction.
- Coastal vegetation, particularly mangroves could stabilize shorelines and prevents wave erosion. The mangroves provide habitat for wildlife and nursery for many marine species. The destruction of coastal vegetation could thus lead to undesirable imbalances in the coastal ecology. It is therefore extremely important that mapping and evaluation of mangroves and other coastal vegetation is considered in the ICZMP. Efforts are being made by the government to create wetland for mangrove plantations.
- The discharge of heated water from the cooling systems of power generation plants along urban settlements, a good example being the Hirgigo Power Plant in Massawa, should be properly managed. The water should be cooled before reaching the marine environment. If possible, the water should be circulated to minimize damage to marine life and coastal vegetation, particularly mangroves.
- The development of appropriate institutional and technical capacities for the establishment of a comprehensive ecological, oceanographic and meteorological information system is essential for developing a visionary adaptive strategy of coastal



areas. This capacity is now lacking and future coastal adaptation strategies should consider this matter seriously.

Data from UNCTAD, IPCC and Eritrea's initial National Communications (NC) completed in December 2001.

## Ethiopia



### **Statistics**

Population	59.7 million
GNP per capita	US \$100

### **Percentage share of GNP**

Agriculture and livestock	49.8%
Industry	6.7%
Services	43.5%
Gross Domestic Investment	18.2%
Main Export	Coffee (36.1% of total export)

### **Vulnerabilities to Climate Change**

“Climate Change may have far reaching implications for Ethiopia for various reasons. Its economy mainly depends on agriculture, which is sensitive to climate variations. A large part of the country is arid and semiarid and is highly prone to desertification and drought. It has a fragile highland ecosystem, which is currently under stress due to population pressure. Forest, water, and biodiversity resources of the country are also climate sensitive. Vector-borne diseases, such as malaria also affect Ethiopia, which are closely associated with climate variations. Climate change is therefore a case for concern.” (NC p.68)

- Population is currently 61.7 million, 85% of which lives in rural areas. By 2030 the population is expected to reach 129.1 million.
- The Canadian Climate Change Model (CCCM), the Geophysical Fluid Dynamics Laboratory Model (GFDL), the United Kingdom Meteorological Office-1989 Model (UKMO-1989), and the GFDL-transient Models were all used to predict climate change scenarios for the country.
- All models showed an increase in rainfall in all regions, although to varying degrees.
- Trend analysis shows a decrease in annual rainfall in the northern half and southwestern regions of the country, and an increase in central Ethiopia. However, overall, the annual rainfall for the entire country has remained constant from 1961 to 1990.
- In the past 50 years the temperatures in Ethiopia have been increasing, with the annual min increasing by 0.25°C every decade and the maximum increasing by 1°C every decade.

### Agriculture

- The NC climate change analysis was made using wheat and sorghum as case examples. Wheat and sorghum are two of the five major crops in the country.

- All models showed a decrease in the maturity period of wheat, ranging from 10.6-18.5%.
- For sorghum, the CERES-Sorghum Model predicted an increase in crop yield with an increase in biomass and nitrogen uptake.

“Climate change would affect grassland and livestock sector in many ways such as change in pasture productivity in quantity and quality, change in livestock productivity, change in distribution and incidence of animal and plant disease. Climate change variability and drought is a major challenge for this sector. The impact of climate change on grazing land, as a result of temperature increase and shift of rainfall pattern will affect animal production and a decline in the livestock sector will severely affect the economy of the country. In addition the biodiversity inhabiting the areas would be in jeopardy. Therefore, the compounded effect would bring about high degree of vulnerability on the resource as a whole.” (NC p.80)

#### Forestry

“Under changed climate scenarios, change in forests from one type to another, shifting of forests from old to habitat, reduction of areas of forest coverage, fragmentation of forest life zones, disappearance of montane and lower montane wet forest and subtropical desert scrub are expected.” In addition, the appearance of tropical moist forest and expansion of tropical dry and very dry forests are projected. “The expansion of tropical desert scrub and tropical dry and very dry forests and on the other hand [high] shrinkage of lower montane moist forests in the northern parts of the country could be the result of predicted temperature increase by 2.4-3°C as well as rainfall decline by about 5%.” (NC p.81)

#### Water Resources

- Vulnerability for water resources was done using studies of the Awash and Abay river catchments.
- Both appear to be “highly vulnerable” to climate change.
- Run-off will decrease under warmer, drier conditions.

#### Wildlife

- Shifting of biomes, disease, sea level rise, the timing of seasons, habitat fragmentation, and human stress will all harm the existing wildlife in the country.

#### Human Health

- The NC focused on the problems of malaria, which is projected to become more widespread under climate change conditions.

#### **Current or Recommended Strategies for Climate Change Adaptation**

- The Conservation Strategy and the 1993 Environmental Policy are supposed to improve many of the environmental problems like soil erosion, deforestation, desertification, etc.

#### Agriculture Sector

- Improving and changing management practices and techniques such as planting date, seeding rate, fertilizer application rate, etc;
- Change in crop regions;
- Proper use of climate information for land use planning and early warning systems etc.
- Promoting irrigation agriculture;
- Enhancing erosion control;
- Adopting suitable crop varieties and developing new ones
- Note that fertilizer additions under doubling CO<sub>2</sub> shows a decrease in crop yield in most regions studied.

### Livestock Sector

#### *Options for the highlands:*

- Selection of crops and cropping systems that maximize biomass production and therefore, CO<sub>2</sub> and N<sub>2</sub> fixation;
- Improved animal genotype and better disease parasite control to take advantage of the improved management; and
- Use of multipurpose cattle that work and provide milk and meat and also breed to provide suitable drought animals, in addition to supplying fuel and fertilizer from their excreta.

#### *Options for lowlands/rangelands:*

- Strengthening the early warning systems and coping strategies;
- Introduce mixed farming system, where appropriate;
- Restocking of livestock on a regular basis;
- Water resource development in appropriate sites;
- Promote lifestyle choices of pastoralists through access to education and local urban development;
- Rehabilitation of bush encroachment areas;
- Conservation and utilization of hay from natural pastures (hay making with local grasses);
- Promotion of herd diversification;
- Promotion of grazing management schemes;
- Use of local legume forage including acacia fruits and leaves;
- Capacity building and institutional strengthening of the local community; and
- Integrated approach to pastoral development.

### Forestry Sector

- Planting trees and establishing plantations;
- Adopting sustainable forest management practices;
- Environmental education and training;
- Maintain untouched forest lands and river banks as migration corridors;
- Promoting conservation/preservation; and
- Developing disaster resistant tree species.

### Water Resources

- No modelling technique has been yet applied for the adaptation assessment of the water sector. For the Awash and Abay Basin, the NC recommends allocation of water supply through market-based systems, control of pollution, conservation of water and use of river basin planning and coordination.

### Wildlife

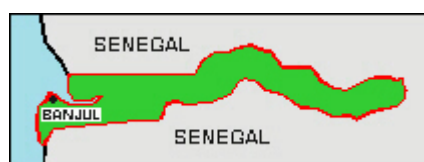
- Avoid habitat destruction and fragmentation;
- Protect and enhance migration corridors or buffer zones;
- Increase public awareness about the use of wildlife;
- Improve wildlife and ecological surveillance systems;
- Improving land use planning;
- Improve farming and husbandry practices;
- Avoid induced species;
- Minimize population pressure;
- Reduce pollution from industrial effluents;
- Ecosystem, wetland, watershed conservation, preservation and protection;
- Ensure benefits from wildlife and sanctuaries from local community.

### Human Health

- Establish and strengthen surveillance system;
- Promote integrated vector control approach;
- Improve management of ecosystems which are sensitive to malaria invasion;
- Plan developmental activities that encompass malaria control;
- Strengthen research in the health sector;
- Educate the public about malaria;
- Encourage utilization of climate and meteorological information in planning of malaria control;
- Encourage the use of malaria bed nets; and
- Develop effective malaria drugs.

Data from UNCTAD, IPCC and Ethiopia's initial National Communications (NC) completed in June 2001.

### Gambia



### **Statistics**

Population	1.2 million
GNP per capita	US \$340

### **Percentage share of GNP**

Agriculture and livestock	27.4%
Industry	13.7%
Services	58.9%
Gross Domestic Investment	18.4%
Main Export	Travel (58.8% of total export)

### **Vulnerabilities to Climate Change**

- “[T]he Gambia River flow has been shown to be very sensitive to climate change” and could face a 50% change in runoff. (IPCC p.499)
- Salt water intrusion into the Gambia River.
- Gambia’s capital, Banjul, “could disappear in 50-60 years through coastal erosion and sea-level rise, putting more than 42,000 people at risk”. (IPCC p.515)

Data from UNCTAD and IPCC.

## Lesotho



### **Statistics**

Population	2.1 million
GNP per capita	US \$570

### **Percentage share of GNP**

Agriculture and livestock	11.5%
Industry	42.0%
Services	46.5%
Gross Domestic Investment	48.6%
Main Export	Clothing (42.8% of total export)

- Due to its location on the plateau of the southern Africa subcontinent, the country's climate is greatly influenced by both the Indian and Atlantic Oceans, two oceans with wide temperature differences.
- The weather patterns of the two oceans determine the movement of the Inter Tropical Convergence Zone (ITCZ) that in turn determines whether the Lesotho year is wet or dry.
- 85% of the population lives in rural areas, 70% of which derive their living from agriculture.
- The geography of the country is such that it has limited arable land, high climate variability and severe soil erosion due to the topography of the land.

### ***Vulnerabilities to Climate Change***

An increase in precipitation in the winter would bring "heavier snow and devastating winds which often bring disasters and human suffering." (NC p.ix)

### ***Water Resources***

- GCM simulations indicate reduced surface and sub-surface runoff due to climate change as a result of lower precipitation.
- Combining the GCM models with the projected increase in population, it is predicted that Lesotho will enter a water stress phase in 2019 and a water scarcity phase by 2062.
- Possible conflict with South Africa over water resources.

### ***Agriculture***

- Crop production is dominated by maize, which accounts for 63% of the area planted (in 1995/96). The second largest crop is sorghum (28% in 1995/96) and then wheat at 12% (1995/96).
- GCM models predict a slight improvement to maize production under climate change conditions.
- Climate change impact on sorghum production is "somewhat indeterminate". (NC p.x)
- Dry bean production will fall slightly.

- Higher temperatures, poor grass cover, reduced rainfall, and the already frequent droughts and storms are likely to increase the rate of soil erosion (which is already close to 40 million tons per year).

#### Wildlife

“Since Lesotho is likely to experience a warmer climate in future, it is likely that the species diversity will improve, either through migrations, or through improved adaptation of imported species. On the other hand, with lower rainfall in the spring and summer seasons, it is those species which thrive in dry land areas that are likely to proliferate in the future, resulting in an improvement in the number of herbal, floral, and reptile species which are characteristic of dry forests.”

- Unfortunately, climate change may not allow for the gradual changes necessary for species adaptation so, unless conservation measures are carried out, many species in the country will become extinct.

#### Human Health

“So far Lesotho is free from many climate-related diseases that are common in tropical countries because of high altitude and severe winter temperatures.” (NC p.xi)

“The complex relationship between water quality and availability and sanitation and hygiene on the other hand, and disease prevalence on the other, is well demonstrated where respiratory tract infections, gastro-intestinal, genito-urinary, and skin diseases atop the list of reported cases, together constituting 55% of these cases.” (NC p.xi)

- An increase in temperatures may lead to the migration of diseases to areas normally protected by colder climates.
- Drier climate in the spring and summer will increase the occurrence of respiratory tract infections like tuberculosis and waterborne diseases like typhoid. More severe winter conditions will also increase the chance of respiratory illness.

#### Forestry

- Relatively little data is available on the forest cover of the country, although it is generally known that Lesotho is “one of the least forested in Africa”. (NC p.x)
- The Holdridge Life Zone Classification model shows the potential for widespread occurrence of sub-tropical dry forest and temperate moist forest cover, which would “impact positively on afforestation programs” in Lesotho. (NC p.x)
- The Forest Gap model supports this as well.

#### Rangeland

- Rangeland utilization is a highly political issue in Lesotho.
- The SPUR model predicts that under reduced or delayed precipitation the nutritious climax grass species would be replaced by hardier, less nutritious varieties. which would have serious implications for the livestock economy.

*Data from UNCTAD, IPCC and Lesotho's initial National Communications (INC) completed in April 2000.*

### Malawi



#### **Statistics**

Population	10.4 million
GNP per capita	US \$210

#### **Percentage share of GNP**

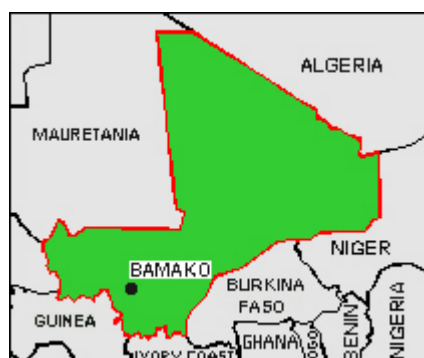
Agriculture and livestock	35.9%
Industry	17.8%
Services	46.4%
Gross Domestic Investment	13.7%
Main Export	Tobacco (59.9% of total export)

#### **Vulnerabilities to Climate Change**

- Endorheic (closed) lakes are “very dependent on the balance of inflows and evaporation and are very sensitive to change in either.” (IPCC p.205). Lake Malawi can be regarded as “practically endorheic”. (IPCC p.205)
- Increase in vector-borne diseases like African Trypanosomiasis (sleeping sickness).

Data from UNCTAD and IPCC.

### Mali



#### **Statistics**

Population	10.7 million
GNP per capita	US \$250

#### **Percentage share of GNP**

Agriculture and livestock	46.9%
Industry	17.5%

Services	35.6%
Gross Domestic Investment	20.9%
Main Export	Cotton products (48.4% of total export)

### ***Vulnerabilities to Climate Change***

#### *Agriculture Sector*

- A correlation between the Gfd3 model and the CCCM model predicts that by 2025, the average temperature rise will be between 2.71 and 4.51°C, while there will be a decrease in rainfall of 8-10% and a decrease in insolation between 1-10%.
- Under these conditions the effects on sorghum crops will be:
  - With a 4% rise in temperature there will be a 16% decrease in yield for the Tiémantié variety, which will cause food shortages for 12% of the region's population.
  - Also, a 12% decrease in yield for the CSM388 variety, which will cause a food ration for 44% of the region's population.

#### *Water Resources*

- If current trends continue unabated there will be a temperature rise of 0.4-1.1°C and a decrease in rainfall of 12 to 29% by 2025. However, a doubling of CO<sub>2</sub> concentration will result in a 15% increase in rainfall by 2025.

### ***Current or Recommended Strategies for Climate Change Adaptation***

#### *Agriculture Sector*

“Resourceful diversification responses by women in Bambara and Fulbe households in Mali reflect the importance of women in guiding adaptation strategies across Africa.” (IPCC p.520)

- Following the droughts in the 1970s, the Mali Government set up “a two-pronged approach” to tackle drought:
  - Keeping decision makers and agricultural officers well informed about the state and development of agro-pastoral fields looking at several indicators such as meteorological indicators, rainfall, water reports, hydrological indicators, etc.
  - Also, providing the rural community with technical knowledge so that they are able to better plan their crop production.
- An agro-hydro-meteorological bulletin is released every ten days, which acts as an early warning system for farmers.

“An outcome of these strategies [of the agro-hydro-meteorological scheme], production has increased by an average of 42% for millet, 35% for sorghum and 68% for maize, within the entire area covered by these activities.” (Konate p.7) Also, with the calendars showing ideal planting times, “there has been a significant reduction in seed planting failure, which decreased from 40% to 5%”. (Konate p.7)

- Between 1990 and 1996, the cost-benefit of this agro-meteorological assistance was observed to be 1/21. “Which means that for every franc invested, a profit of 21 francs was realised.” (Konate p.7)
- The agro-meteorological scheme was established in 1982 with Suisse financial support, and technical assistance by the World Meteorological Organization. The scheme has several objectives, which include the inclusion of rural communities in new projects, the provision of professional training for local farmers and the introduction of agro-meteorological information, the compilation of agro-meteorological information to advise farmers, the preparation of forecast tables, and the establishment of a rural database to help with agro-meteorological work.



Konate recommends:

- Genetic modifications of certain species.
- Improvement of agricultural techniques.
- Reinforcement of agro-meteorological assistance.
- Decision-makers must be well informed about the current future agricultural system in relation to climate change.

#### Water Resources

In the 1980s, the Mali government established several new strategies to meet the water demand:

- Development of the village and pastoral water supply system, through the construction of a number of wells, equipped with manual pumps;
- Development of urban water supply, through the construction of a supply system, fed either from surface waters or from high capacity wells;
- Development of the agricultural water supply system, fed from surface water obtained from rivers in the region.

Konate argues that this system has “proved its worth” in spite of shortcomings observed in the Malian Water Resources Development Plan.

- Another adaptation strategy would be the construction of water supply systems covering entire urban communities.
- In addition, the deepening of 200 ponds and shallow wells for livestock.
- The construction of a number of small dams.
- Exploitation of underground water resources as an alternative to surface water.
- Construction of embankments and drains for flood protection, and an evacuation plan for flooding.
- Constant monitoring of water quality.
- New programmes to mitigate silting of riverbeds, especially for the river Niger.
- More quantitative and qualitative evaluation of renewable resources for a better understanding of the Malian surface and ground water resources.

#### The Energy Sector

- Determination of the efficiency of locally manufactured energy saving technologies (ovens, charcoal cookers and stoves, kerosene stoves);
- Determination of the efficiency of some locally manufactured appliances, which use alternative forms of energy to wood, such as briquettes, charcoal formed from agricultural wastes, coal dust concentrates, etc;
- Selection of the most efficient energy sources;
- Increased production of energy saving technologies (ovens, cookers and stoves using charcoal from agricultural wastes, kerosene stoves);
- Promotion and distribution of alternative technologies and combustion fuels;
- Promotion of photovoltaic solar equipments for household lighting.
- Energy manufacturing equipments should be produced locally.

#### Biodiversity

“Vast expanses of the arid region of Mali are undergoing serious degradation, due to the combined effects of: unfavourable climatic conditions which reduced productivity over the entire region; local exploitations of pastoral lands, which has become uncontrollable and destructive; extension of farming into more humid areas, thus reducing the reserve of fodder crops and the extent of pastoral lands.” (Konate p.12)

- And with decreasing rainfall the pastoral exploitation of the land increases.
- The Ministry of the Environment is starting a new programme which hopes to:

- Set up an integrated development demonstration programme, explaining the sustainable use of local resources (land, plants, water, energy, livestock resources, etc);
- Ensure the stability of the natural resources management system;
- Render traditional management systems more resistant to unfavourable climatic conditions;
- Select options which could be extended to similar arid zones.

Data from UNCTAD and Konate M. (2002) "Alternative Mechanism and Strategies for Adaptation to Climate Change for the Least Developed Countries."

### Mozambique



#### **Statistics**

Population	18.9 million
GNP per capita	US \$210

#### **Percentage share of GNP**

Agriculture and livestock	34.3%
Industry	20.8%
Services	44.8%
Gross Domestic Investment	20.4%
Main Export	Business Services (42.7% of total export)

#### **Vulnerabilities to Climate Change**

##### Water Resources

- Floods in 2000 demonstrated how existing water management is not working as expected to minimize risk and loss.
- La Nina caused devastating floods in 1999-2000. Modelling exercises showed an increase in frequency in El Nino and La Nina cycles.
- Studies show there is a decrease in surface and subsurface run off in five streams in Mozambique, including the Zambezi basin, which has a projected decrease in run-off of 40% or more.

##### Human Health

- Increase in vector-borne diseases like Dengue Fever.
- Increase in the range of tsetse fly.
- The plague is a fly-borne disease carried by rodents. After heavy rainfall rodent populations can rapidly increase. Plague outbreaks have been observed in Mozambique.

Data from UNCTAD and IPCC.

## Niger



### **Statistics**

Population	10.1 million
GNP per capita	US \$200

### **Percentage share of GNP**

Agriculture and livestock	41.4%
Industry	17%
Services	41.7%
Gross Domestic Investment	10.4%
Main Export	Uranium (39.4% of total export)

### **Vulnerabilities to Climate Change**

- For the river Niger, the IPCC estimates an increase in precipitation of 10%, a 10% increase in evaporation and 10% increase in runoff.

“In Niger, farmers with access to credit will adopt low-cost, appropriate technologies for wind erosion control, including windbreaks, mulching, ridging, and rock beds.” (IPCC p.520)

*Data from UNCTAD and IPCC.*

## Senegal



### **Statistics**

Population	9 million
GNP per capita	US \$520

**Percentage share of GNP**

Agriculture and livestock	17.4%
Industry	24.1%
Services	58.5%
Gross Domestic Investment	19.6%
Main Export	Fish (19.8% of total export)

- The human carrying capacity for the Senegal Sahel is calculated to be 13 people per square km. In 1998, the population density was 45 people per square km.

**Vulnerabilities to Climate Change**

Coastal Areas

- Impacts on Mangrove forests that have “important ecological and sociological functions, particularly in relation to seafood production, as a source of wood products, as nutrient sinks, and for shoreline protection.” (IPCC p.360)
- However, depending on the specific setting, Mangrove forest may be able to withstand sea-level rise, and in protected low-level areas may even expand in territory.

Water Resources

“The SRB [Senegal River Basin] is undergoing fundamental environmental, hydrologic, and socioeconomic transitions ... though the river basin development authority, the Organisation pour la Mise en Valeur du Fleuve Senegal (OMVS) are promoting irrigated rice production for domestic consumption in the river basin to ease the severe foreign exchange shortfalls facing these riparian nations.” (IPCC p508)

- The construction of the Manantali and Diama dams now mean year round crop production.

**Current or Recommended Strategies for Climate Change Adaptation**

- The Sereer in Senegal have achieved doubling of tree densities in certain semi-arid areas with *Acacia albida*.

Data from UNCTAD and IPCC.

**Somalia**



**Statistics**

Population	9.2 million
GNP per capita	US \$200

**Percentage share of GNP**

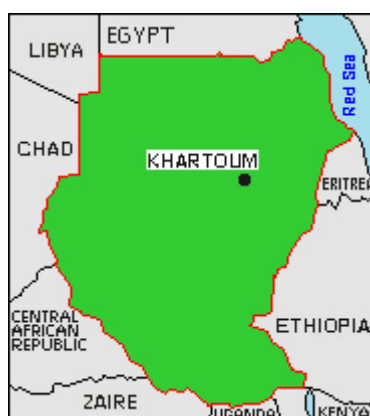
Agriculture and livestock	unknown
Industry	unknown
Services	unknown
Gross Domestic Investment	unknown
Main Export	Livestock (44.3% of total export)

**Vulnerabilities to Climate Change**

- Increase in vector-borne diseases like Dengue Fever. (IPCC p466)

Data from UNCTAD and IPCC.

**Sudan**



**Statistics**

Population	28.3 million
GNP per capita	US \$290

**Percentage share of GNP**

Agriculture and livestock	39.3%
Industry	18.2%
Services	42.6%
Gross Domestic Investment	unknown
Main Export	Sesame seeds (19.7% of total export)

**Vulnerabilities to Climate Change**

- Confined aquifers in the Sudan “may not be seriously affected by seasonal or interannual rainfall or temperature of the local area.” (IPCC p200)
- Visceral Leishmaniasis.

Data from UNCTAD and IPCC.

### Uganda



#### **Statistics**

Population	20.6 million
GNP per capita	US \$310

#### **Percentage share of GNP**

Agriculture and livestock	44.6%
Industry	17.6%
Services	37.8%
Gross Domestic Investment	15.1%
Main Export	Coffee (53.7% of total export)

#### **Vulnerabilities to Climate Change**

- The plague is a fly-borne disease carried by rodents. After heavy rainfall rodent populations can rapidly increase. Plague outbreaks have been observed in Uganda.

Data from UNCTAD and IPCC.

### United Republic of Tanzania



#### **Statistics**

Population	32.1 million
GNP per capita	US \$220

#### **Percentage share of GNP**

Agriculture and livestock	45.7%
Industry	14.9%
Services	39.4%

Gross Domestic Investment	15%
Main Export	Travel (34.9% of total export)

**Vulnerabilities to Climate Change**

“There is currently no indication that the broad pattern of seasonality is likely to change in the Serengeti or the Kalahari, since they are controlled by gross features of the atmospheric circulation. The intensity of seasonality, and the absolute annual rainfall total could change, by 15% in either direction.” (IPCC p.511)

*Data from UNCTAD and IPCC.*

**Zambia**



**Statistics**

Population	8.8 million
GNP per capita	US \$330

**Percentage share of GNP**

Agriculture and livestock	17.3%
Industry	26.4%
Services	56.3%
Gross Domestic Investment	14.3%
Main Export	Copper (70.6% of total export)

**Vulnerabilities to Climate Change**

- Increase in Meningitis.

*Data from UNCTAD and IPCC.*

## **ASIA**

### **Afghanistan**



#### ***Statistics***

Population	21.4 million
GNP per capita	unknown

#### ***Percentage share of GNP***

Agriculture and livestock	unknown
Industry	unknown
Services	unknown
Gross Domestic Investment	unknown
Main Export	Dried fruit and nuts (51.3% of total export)

#### ***Vulnerabilities to Climate Change***

- Based on 1995-97 statistical information, 62% of the country's population is undernourished, so if climate change does in fact negatively impact the agricultural production as projected, then the situation will become worse.

*Data from UNCTAD and IPCC.*

### **Bangladesh**



#### ***Statistics***

Population	124.8 million
GNP per capita	US \$350

#### ***Percentage share of GNP***

Agriculture and livestock	22.2%
Industry	27.9%



Services	49.9%
Gross Domestic Investment	22.2%
Main Export	Garments (52.3% of total export)

### ***Vulnerabilities to Climate Change***

“[I]f there were no significant adaptive responses, a 1 m sea-level rise would decrease the area of Bangladesh by 17.5%.” (IPCC)

- Low-lying cities like Dhaka have already witnessed great environmental stress.
- Following a temperature rise of 0.5-2°C, and consequently a 10-45 cm rise in sea-level, the Bangladesh Sundarbans will face inundation of 15% (~750 km<sup>2</sup>), an increase in salinity, loss of plant species and wildlife, and thus economic loss, insecurity and greater unemployment.
- Following a temperature rise more than 2°C, (with change in rainfall and a 45 cm rise in sea-level) the Bangladesh lowlands will face inundation of between 23-29%, a change in flood depth category, a change in the monsoon rice cropping patterns, risk of life and property, increased health problems and a reduction in rice yield.

### ***Agriculture Sector***

- Rice and wheat yields will fall 10-17%, based on climate scenarios CCC and GFDL.
- Rapid decline in grain self-sufficiency seen with growing populations. In countries such as Bangladesh, which have “long maintained grain self-sufficiency of more than 90%”, these countries may also see declines as they shift towards industrialization. (IPCC p.559)
- Famine risk will increase.
- Based on 1995-97 statistical information, 37% of the country’s population is undernourished, so if climate change does in fact negatively impact agricultural production as projected, the situation will become worse.

### ***Coastal Areas***

“Storm-surge flooding in Bangladesh has caused very high mortality in the coastal population (e.g., at least 225,000 in November 1970 and 138,000 in April 1991), with the highest mortality among the old and weak.” (IPCC p.366)

“Land that is subject to flooding – at least 15% of the Bangladesh land area – is disproportionately occupied by people living in a marginal existence with few options or resources for adaptation.” (IPCC p.366-7)

- Floods cover 3.1 million ha, and conversely about 2.7 million ha are vulnerable to droughts annually. “[T]here is about 10% probability that 41-50% of the country is experiencing drought in a given year.” (IPCC p.544)
- “The intensity of extreme rainfall events is projected to be higher in a warmer atmosphere, suggesting a decrease in return period of extreme precipitation events and the possibility of more frequent flash floods in parts of ... Bangladesh.” (IPCC p550) Other studies contradict these findings.

### ***Biodiversity***

“The Sundarbans of Bangladesh, which support a diversity of wildlife, are at greater risk from rising sea level. These coastal mangrove forests provide habitat for species such as Bengal tigers, Indian otters, spotted deer, wild boar, estuarine crocodiles, fiddler crabs, mud crabs, three marine lizard species, and five marine turtle species...With a 1 m rise in sea level, the Sundarbans are likely to disappear, which may spell the demise of the tiger and other wildlife.” (IPCC p.556)

Water Resources

- The Ganges-Brahmaputra in Bangladesh is one of the “key low-lying river deltas in tropical Asia that are most vulnerable to sea-level rise”. (IPCC p.578)
- Increased glacier melt “may cause serious floods” in Bangladesh. (IPCC p.579)

Human Health

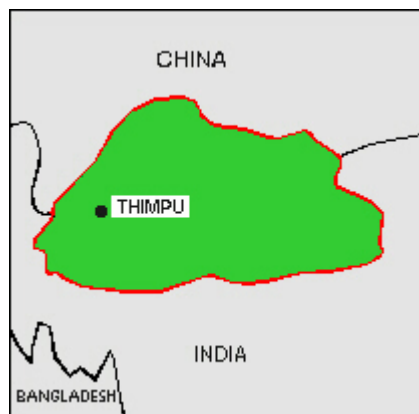
- Potential increase in Visceral Leishmaniasis and Cholera, which is facilitated by the copepod zooplankton that provides a marine reservoir for the disease.
- Tropical cyclones are one of the most “critical factors” affecting the loss of human life in Bangladesh. “Approximately 76% of the total loss of human lives from cyclonic storms has occurred in India and Bangladesh.” (IPCC p.569) The concern is that cyclones and tropical storms will change with climate change, possibly becoming more intense and more frequent.
- With a 45 cm rise in sea-level, Bangladesh could face a land loss of 15,668 km<sup>2</sup> (or 10.9% of the total land area) which, in turn, would affect 5.5 million people (5% of the population).
- Malaria is still “one of the most important diseases” in Bangladesh. (IPCC p.571)
- The cholera outbreak in 1994 is attributed to extended phytoplankton blooms that are encouraged with higher surface sea temperatures and increased nutrient loading.

**Current or Recommended Strategies for Climate Change Adaptation**

- Coastal natural conservation parks are established in Bangladesh, but land ownership and management responsibility issues have inhibited their proper management.

Data from UNCTAD and IPCC.

**Bhutan**



**Statistics**

Population	0.6 million
GNP per capita	US \$470

**Percentage share of GNP**

Agriculture and livestock	38.2%
Industry	36.5%
Services	25.4%
Gross Domestic Investment	47.3%
Main Export	Electricity (24.9% of total export)

- In recent years signs of unusual change in climatic systems have been seen. A rare dry-spell with no snowfall was experienced in the winter of 1998 and even rarer mid-summer snowfall occurred in some places in the north in July 1999.
- Flash floods in August of 2000.

### ***Vulnerabilities to Climate Change***

#### *Forests and Biodiversity*

- Temperature changes could create “competition between high-elevation tree species and new arrivals”. (NC p.38)
- The protection of Bhutan’s biodiversity is especially important considering it is one of the world top ten “hotspots” for biodiversity on the planet.
- Climate change models show that climate change will be most “severe on fragile mountain ecosystems and island states”. Since Bhutan is in a mountain ecosystem it is highly vulnerable. (NC p.37-8)

“Weedy species with a high ecological tolerance will have an advantage over cold-adapted species. While warming may have positive effects on the growth of some trees, it also could reduce tree survival by benefiting insects and pests. Warmer winters would imply reduced snow cover and less carryover of water to the growing season, which could lead to drought-induced forest decline.” (NC p.38)

#### *Agriculture*

- The main crops in Bhutan are rice, wheat, maize and potato.
- Upland crops are grown at the “margins of viable production”, so sensitive to even slight climatic changes. (NC p.38-9)
- Bhutan will face direct effects of changes in temperature, precipitation and carbon dioxide concentrations, as well as indirect effects from changes in soils, distribution and frequency of pest species, diseases and weeds.
- Increased temperatures would allow crops to be grown further upslope, yet steep slopes may be unsuitable for planting.
- Increased temperatures may also bring new invasion species and diseases.

#### *Water Resources*

- Bhutan has easy access to rivers, streams and natural pond water made available by glaciers, snow and seasonal rainfall.
- “Although Bhutan did not record water shortages till now, climate change may render the country highly vulnerable to scarcity of water.” (NC p.40)
- “Water resources in the tropical Asia region, covering Bhutan, are sensitive not only to changes in temperature and precipitation but also to changes in tropical cyclones.” (NC p.40)
- Increase in precipitation would also increase surface run-off and soil erosion.

“A reduction in the average flow of snow-fed rivers, combined with an increase in peak flows and sediment yield, would have major impacts on hydrological generation, urban water supply and agriculture.” (NC p.40)

- Increase in temperatures may also lead to the “retreat of glaciers, increasing the volume of [glacier] lakes and ultimately provoking glacial lake outburst floods (GLOFs).” (NC p.40). This was seen with the flash flood on the Pho Chhu river in October 1994.

#### *Human Health*

“A predicted temperature increase of 2°C is likely to affect human health not only because of heat stress but also because of increased outbreaks of vector-borne diseases.” (NC p.41)

- An increase in flooding would favour water-borne diseases, such as gastroenteritis and diarrhoea.
- Malaria and cholera outbreaks in the recent past.

### ***Current or Recommended Strategies for Climate Change Adaptation***

#### *Forestry and Biodiversity*

- Community-based forest management and afforestation projects with the purpose of conservation.
- Research into developing a sustainable socio-economic system.
- Research into tree species that are fast growing and more resistant to insect damages from diseases and disturbance events.
- Improvements in databases for natural resources.
- In recent years, the Royal Government banned the export of raw timber.

#### *Agriculture*

- Need to develop varieties of crops and livestock with greater resistance to limited arable land and extreme temperatures.
- Quarantine surveillance should be increased.
- Agro-forestry and agro-silvo-pastoral systems may be utilized to reduce erosion and runoff on steep slopes, and to mitigate heat stress and respiration problems and fertility loss.

#### *Water Resources*

- Community involvement and awareness.
- Land use planning should be improved to promote afforestation in degraded water catchments.
- Improvement of water supply infrastructure, including water tanks, pipes etc.

#### *Human Health*

- A reliable and safe drinking water supply is essential.
- Water treatment plants should be built.
- Development of proper waste disposal methods needs to be encouraged to minimize the existence of vector breeding habitats.
- Regular cleaning and vaccination campaigns where the mosquito vector is abundant.

*Data from UNCTAD, IPCC and Bhutan's initial National Communications completed in September of 2000.*

### **Cambodia**



#### ***Statistics***

Population	10.7 million
GNP per capita	US \$260

**Percentage share of GNP**

Agriculture and livestock	50.6%
Industry	14.8%
Services	34.6%
Gross Domestic Investment	15%
Main Export	Saw timber (25.3% of total export)

**Vulnerabilities to Climate Change**

Agriculture

- Based on 1995-97 statistical information, 33% of the country’s population is undernourished, so if climate change does in fact negatively impact agricultural production as projected then the situation will become worse.

Human Health

- Malaria is still “one of the most important diseases” in Cambodia. (IPCC p.571)

Data from UNCTAD and IPCC.

**Lao People’s Democratic Republic**



**Statistics**

Population	5.2 million
GNP per capita	US \$320

**Percentage share of GNP**

Agriculture and livestock	52.6%
Industry	22.0%
Services	25.4%
Gross Domestic Investment	24.9%
Main Export	Wood products (27.3% of total export)

- Mountainous topography with wide network of rivers.
- South-west monsoon.

“The climate is characterized by high interannual variability of rainfall with relatively frequent occurrence of flooding and drought.” (NC p.13)

- No expected water problems in the foreseeable future.

- Forest cover is 47% of the total area. However, “[o]ver the past two decades forest areas have decreased due to shifting cultivation practices, poorly planned logging activities, and forest fires.” (NC p.13)
- High mortality rate and low life expectancy in the country due to poor health services.
- The three leading causes of child mortality are malaria, acute respiratory illness and diarrhoea, in that order.
- 81% of cropland is devoted to rice production, with 65% of that grown in the lowlands.
- Other crops include coffee, maize, starchy roots and soybeans.

### ***Vulnerabilities to Climate Change***

“The Lao PDR is highly dependent on natural resources for its prosperity: agriculture, forest resources, and water resources. The likely transitions in climate change will, therefore, not only have physical impact on these resources but also a larger impact on the socio-economic situation of the country. There has been no study on the vulnerability of different sectors to climate change in the country. Such a study is necessary in view of likely impacts, so that appropriate adaptation measures can be designed to minimize any likely future impacts.” (NC p.95)

#### *Water Resources*

- Drought disasters more frequent during ENSO events.

#### *Agriculture*

- Based on 1995-97 statistical information, 33% of the country’s population is undernourished, so if climate change does in fact negatively impact agricultural production as projected, the situation will become worse.

#### *Human Health*

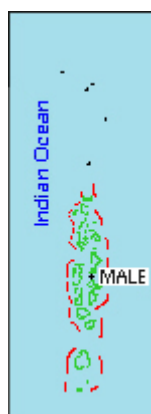
- Malaria is still “one of the most important diseases” in Laos. (IPCC p.571)

### ***Current or Recommended Strategies for Climate Change Adaptation***

The main goals for the government are to “increase public awareness activities on climate change; implement a GHG mitigation plan; regularly monitor and control climate change activities, for example data collection on temperature, rainfall, water flow, etc; and cooperate with international agencies on climate change activities and related issues.” (NC p.61)

*Data from UNCTAD, IPCC and the initial National Communications.*

### **Maldives**



### ***Statistics***

Population 0.3 million

GNP per capita US \$1,130

**Percentage share of GNP**

Agriculture and livestock	16.4%
Industry	unknown
Services	unknown
Gross Domestic Investment	unknown
Main Export	Travel (71.0% of total export)

- As a low-lying, small island state, Maldives is extremely vulnerable to sea level rise and natural disasters, which compounded by the fact that the country’s economy is heavily dependent on coastal ecosystems.

**Vulnerabilities to Climate Change**

“The main concern for the Maldives would be sea level rise. The rise in sea level would lead to, or exacerbate, land loss from beach erosion and inundation and also damage human settlements and vital infrastructure. Maldives would also be highly vulnerable to rising air and sea surface temperatures and changes in rainfall patterns.” (NC p.49)

- Using the CSIRO-Mk2 IS92 (a and e) and HaDCM2 IS92 (a and e), it was determined that by 2025, the temperature would increase between 0.4°C to 1.0°C, rainfall would increase from 1.6% to 18.9% and sea levels would rise from 9.3 to 19.7 cm. By 2050, the temperature would increase between 0.9°C to 1.7°C, rainfall would increase by 3% to 39.7%, and sea level would rise by 19.9 to 39.7 cm.
- By 2100 “the temperature may have increased by between 2.0°C and 3.8°C and sea level may rise between 48 cm to 95 cm”. Rainfall will increase from 5.9 to 77.4% by 2100. (NC p.50)

Coastal Ecosystems

“The islands of Maldives are among the most susceptible to inundation from water rising from the ground, as well as overtopping dune ridges.” (NC p.53)

“Being made of coral limestone, the islands of the Maldives are also among the least defensible against sea level rise in the world.” (NC p.53)

- Over 80% of the Maldives island land mass is less than 1 m above sea level, and no island is higher than 3 m above sea level.

“The shapes and sizes of these small islands are characterized by strong tidal and current patterns. The beach systems found on these islands are highly dynamic and have directional shifts within the shoreline in accordance with the prevailing seasonal conditions.” (NC p.53) Roughly 50% of the inhabited islands and 45% of the tourist resorts presently suffer from beach erosion.

Infrastructure

- All of the country’s infrastructure is located between 0.8 to 2m above mean sea level.

“Even now some islands are seriously affected, with loss not only of shoreline but also of houses, schools and other infrastructure, compelling the government to initiate urgent coastal protection measures.” (NC p.59)

- “One of the most vulnerable structures in the Maldives is the Malé International Airport on the Hulhulé island.” (NC p.60) The only international airport in the Maldives.

- It is estimated that US \$57.4 million is needed to protect the airport from the effects of climate change and sea level rise.

#### Coral Reefs

“The most critical impact on coral reefs is likely to be due to the increase in sea surface temperature as observed by the series of coral bleaching and mortality events in the Maldives associated with the elevated sea surface temperature in the Indian Ocean.” (NC p.62)

- Coral bleaching occurred in the Maldives in 1977, 1983, 1987, 1991, 1995, 1997 and 1998. The 1998 event was the most severe ... with more than 90% of corals wholly or partially bleached.” (NC p.62)
- During this 1998 event, the sea surface temperature was 1.2°C to 4.0°C above average during the warmest months.

“The coral reefs of the Maldives are one of the most highly ranked reefs of the world and Maldives is a world-renowned diving destination. It is estimated that about 25% to 35% of tourists visit the Maldives primarily for its excellent diving opportunities, while snorkellers at any one time on a resort can be averaged at 75% to 80%”, therefore, significant coral bleaching would severely harm the tourism industry. (NC p.65)

#### Fisheries

- The Maldives’ fishing industry primarily centres on tuna, which is affected by the monsoon and El Nino events.

“During El Nino years of 1972-73, 1976, 1982-83, 1987 and 1992-94, the skipjack catches and the catch rates were noticeably decreased, while the yellowfin and other tuna species increased.” (NC p.68)

- During the La Nina years, the reverse was observed.
- Although more research needs to be done, decadal scale variations show that the skipjack tuna catch is increasing while the other varieties are decreasing. Fortunately, the skipjack tuna is more important in the global market.

#### Agriculture

- Sea level rise, accompanied by saltwater intrusion of groundwater will threaten agricultural production.

“Already there are problems with freshwater aquifers on several islands including Malé, where most of the mango trees have died.” (NC p.69)

- Of all the crops, taro is the most at risk since it is grown in the wetlands only 40 cm above sea level.
- However, “almost all food requirements, medicines and goods, except fish and coconut, are imported from other countries.” (NC p.69) Therefore, “the vulnerability of Maldives to climate change extends to the agricultural vulnerability of other countries”, namely India and Thailand. (NC p.69)

#### Water Resources

- Saltwater intrusion into groundwater, changes in rainfall, and freshwater availability are all affected by climate change.
- Currently, about 9% of the population does not have access to safe drinking water.
- It is predicted, with low confidence, that precipitation will increase for the Maldives, which could mean more storms, flooding and the formation of new lakes on some islands.



“The Centre for Clouds, Chemistry and Climate (C4) showed that the region is severely affected by transboundary air pollution... [which] has raised concern about the impact on rainwater quality collected from roof catchment.” (NC p.72)

- “Desalinated water has become the major source of water for the capital, Malé.” The present technology used is highly energy intensive, relying mostly on diesel power. (NC p.73)

#### Human Health

- Maldives has only limited health facilities for the population, and “the nearest facilities would be at the regional hospitals or the atoll health centres.” (NC p.75-76)
- Air temperatures in Maldives are expected to rise by 2°C to 3.8°C, and so heat stress related health problems are a concern.
- There have been no studies on the affects of heat stress on the population. Those at greatest risk would be the young and the elderly.
- Physical injury from extreme climatic events may increase.
- The spread of malaria, which is sensitive to climate change, is a major concern, as is the spread of water borne diseases. In particular, certain islands like Fuvahmulah, have steep slopes and are susceptible to flooding which, in combination with poor water facilities, would breed water borne diseases.
- Increase in vector-borne diseases like Dengue Fever.

#### **Current or Recommended Strategies for Climate Change Adaptation**

- After the storm event of 1987, the government underwent many engineering projects to aid the protection of the coastline: a 1.2 km long breakwater constructed on the southern side of the capital, Malé, cost US \$14 million, the seawall on the western, eastern and southern perimeter of the city cost US \$30 million, and the estimated cost of the northern side wall, which is currently under construction, will be US \$14 million. Note that 25% of the country’s population resides in the capital.
- The cost of protecting 50 of the 200 inhabited islands of the Maldives with artificial structures was estimated to be over US \$1.5 billion.

#### Coastal Zones

“Though it is important to protect all the islands of the Maldives, including uninhabited islands, priority has been given to protect the human settlement and infrastructure by focusing first on protecting the inhabited and resort islands.” (NC p.79)

- The Coastal Zone Management Subgroup of the IPCC recognized three response options: retreat, accommodation and protection.
- However, “[t]hese options are only possible where land availability permits and where the ecology, society and economy can afford to do so.” (NC p.80)
- Land is already scarce in the Maldives and the NC does not see retreat inland as a viable option for it involves “abandoning the coastal zone and shifting the associated ecosystems inland”. (NC p.80)

Therefore, solid protection structures such as seawalls may seem “the only realistic option along well-developed coasts, where vital infrastructure and human settlement are at immediate risk.” (NC p.80)

- In terms of the resort islands and their popular beaches, the NC recommends pumping sand from lagoons as a better option for protecting resorts, rather than building coastal structures such as sea walls and groynes.

- However, beach nourishment would have to be carefully prescribed and monitored because sand is an important resource for the islands, especially in the face of climate change.

#### Human Settlements

“Population consolidation may be considered as another adaptive strategy for the Maldives. In the past, population consolidation has occurred for various reasons such as damage from natural disasters, religious reasons and other.” (NC p.80)

- Based on the current financial estimates, building seawalls around 199 of the inhabited islands is not feasible.

“The government has already committed to reduce the number of inhabited islands by developing regional growth centres to provide significant benefits including health and education facilities and employment opportunities to attract migration from smaller and less populated islands. Long-term climate change considerations can also be factored into this policy position.” (NC p.81)

- The development of an effective storm management system will be necessary in the face of increasing extreme storm events, especially for the flood prone areas.

#### Protection of Infrastructure

- As explained before, the infrastructure is highly vulnerable to sea level rise, and the construction of protective sea walls is recommended in the NC.
- It is also recommended that the two domestic airports, Haa Dhaal Hanimaadhoo in the north and Seenu Gan in the south, be upgraded to handle international flights in the case of emergencies.

“This is especially important since most of the food supply is imported by airfreight from other countries.” (NC p.82)

- Also, the establishment of a sea level monitoring programme could help in the planning and protection of future infrastructure developments.
- Current elevation studies are irrelevant for future building developments, because those elevations will change with rising sea levels.

#### Coral Reefs

“The climate change impacts, such as elevated sea surface temperatures and sea level rise, are beyond the control of resource managers. However, the impact of these can be minimized indirectly by reducing the human impacts on coral reefs.” (NC p.83)

“Healthy reefs are more resistant to stresses and are more likely to recover faster than damaged reefs after coral bleaching events.” (NC p.83)

- This will include reducing land-based sources of pollution through “strict policies, particularly on sewage treatment and safe disposal of sewage and solid waste.” (NC p.83)
- Assigning protective status to more reefs is required (currently there are 25 protected sites in the Maldives).
- Diversifying tourism away from diving would also alleviate some stress on the coral reefs. Exploring ecotourism options.
- Or “[d]iving in the Maldives could be promoted as an opportunity for divers to participate in the long-term monitoring of changes on the health of the reefs. In this way, climate change can be used to attract the sophisticated, educated divers of the world. Research and training centres could be established at the dive resorts.” (NC p.84)

### Coral Mining

- Coral mining is practiced because of a lack of alternative building materials.

“Modern building practices have the potential of reducing if not eliminating this traditional practice.” (NC p.81)

“The government of the Maldives has already banned coral mining from the house reefs of islands and has designated specific sites for coral mining.” (NC p.81)

- There could be a complete ban on coral mining on reef flats in order to maintain the coral reef system. However, incentives should be provided to promote the use of imported construction materials – providing other imported materials as an alternative to coral rock at a reasonable price.

“The Government can reduce or exempt import duties on construction materials to facilitate this process of changing traditional habits.” (NC p.81)

### Agriculture

- The islands have very poor soil quality so agricultural production is limited and most food needs to be imported.
- The use of hydroponics could increase local outputs of fruits and vegetables to reduce the present level of imports. Currently the Ministry of Fisheries, Agriculture and Marine Resources is exploring this option.

### Water Resources

“As a means of adapting to water availability, it is important to protect the groundwater lens from all kinds of pollution” and exploit it in a sustainable fashion. (NC p.86)

- Water galleries have proved successful in the Pacific islands and could be used on some of the Maldives islands. For instance, “[a] possible application of such galleries could be its long-term use in the Hulhumalé reclamation site to establish a stable freshwater lens”. (NC p.86)
- Monitoring is vital.
- “Water reuse and recycling on tourist islands needs to be examined to reduce demand for freshwater and the heavy dependence in resorts.” (NC p.86)
- “Increasing the rainwater harvesting roof catchments and the water storage capacity would ensure a more reliable supply of water in the dry period of the northern monsoon.” (NC p.86)
- Educating the population on the importance of safe collecting procedures and the safe treatment of water is vital for this.
- “Solar disinfecting units can be used to treat the collected water at the island community rainwater tanks.” (NC p.86)
- Another technological alternative is the desalination of water using waste heat from powerhouses.

*Data from UNCTAD, IPCC and the initial National Communications completed in 2001.*

## Myanmar



### **Statistics**

Population	44.5 million
GNP per capita	unknown

### **Percentage share of GNP**

Agriculture and livestock	53.2%
Industry	9%
Services	37.8%
Gross Domestic Investment	11.7%
Main Export	Food and live animals (34.6% of total export)

### **Vulnerabilities to Climate Change**

#### Biodiversity

“Frontier forests in Asia are home to more than 50% of the world’s terrestrial plant and animal species”, however these species are becoming increasingly threatened as is currently being seen in Myanmar. (IPCC p.555)

#### Agriculture

- Based on 1995-97 statistical information, 7% of the country’s population is undernourished, so if climate change does in fact negatively impact agricultural production as projected, then the situation will become worse.

#### Human Health

- Malaria is still “one of the most important diseases” in Myanmar. (IPCC p571)

#### Water Resources

- The Irrawaddy in Myanmar is one of the “key low-lying river deltas in tropical Asia that are most vulnerable to sea-level rise”. (IPCC p.578)

Data from UNCTAD and IPCC.

## Nepal



### **Statistics**

Population	22.9 million
GNP per capita	US \$210

### **Percentage share of GNP**

Agriculture and livestock	40.5%
Industry	22.2%
Services	37.3%
Gross Domestic Investment	21.7%
Main Export	Basic Manufactures (38.9% of total export)

### **Vulnerabilities to Climate Change**

#### Agriculture

- Based on 1995-97 statistical information, 21% of the country's population is undernourished, so if climate change does in fact negatively impact agricultural production as projected, then the situation will become worse.
- Higher probability of drought during El Nino years.

#### Human Health

- Potential increase in Visceral Leishmaniasis.
- Increased glacier melt "may cause serious floods" in Nepal. (IPCC p.579)

"The intensity of extreme rainfall events is projected to be higher in a warmer atmosphere, suggesting a decrease in return period of extreme precipitation events and the possibility of more frequent flash floods in parts of ... Nepal." (IPCC p.550) Other studies contradict these findings.

#### Biodiversity

"Besides loss of habitat, wild species are at risk from changes in environmental conditions that favour forest fires and drought. For example, forest fires under unseasonably high temperatures in Nepal may threaten local extinction of red pandas, leopards, monkeys, deer, bears, and other wild animals." (IPCC p.556)

#### Water Resources

"The increase in surface temperature also will contribute to a rise in the snowline, which in effect, reduces the capacity of the natural [water] reservoir." (IPCC p.565)

Watershed management is particularly difficult in Nepal, where many "suffer badly from deforestation, indiscriminate land conversion, excessive soil erosion, declining land productivity, erratic and unreliable surface and groundwater resources, and loss of biodiversity". (IPCC p.566)

Data from UNCTAD and IPCC.

## **CARIBBEAN**

### **Haiti**



#### ***Statistics***

Population	8 million
GNP per capita	US \$410

#### ***Percentage share of GNP***

Agriculture and livestock	30.4%
Industry	20.1%
Services	49.6%
Gross Domestic Investment	10.7%
Main Export	Clothing (29.7% of total export)

#### ***Vulnerabilities to Climate Change***

- Climate change will affect unconfined aquifers, which are replenished directly by local rivers, lakes and by rainfall. The effect climate change will have on the recharge rate of aquifers has been studied in many places, including the Caribbean.
- Sea-level rise would cause a saline intrusion of coastal aquifers.

“For many small island states, such as some Caribbean islands, seawater intrusion into freshwater aquifers has been observed as a result of overpumping of aquifers. And sea-level rise would worsen the situation.” (IPCC p.200)

- Changes in precipitation and a rise in sea-level “would not only cause a diminution of the harvestable volume of water; it also would reduce the size of narrow freshwater lens.” (IPCC p.200)
- There is firm evidence that moisture in the atmosphere is increasing in the Caribbean and western Pacific, indicating conditions of heavier precipitation.

*Data from UNCTAD and IPCC.*

## **PACIFIC**

### **Kiribati**



#### ***Statistics***

Population	0.9 million
GNP per capita	US \$1,170

#### ***Percentage share of GNP***

Agriculture and livestock	20.7%
Industry	6.1%
Services	73.2%
Gross Domestic Investment	unknown
Main Export	Licence fees/royalties (58.5% of total export)

#### ***Vulnerabilities to Climate Change***

“The atolls of Kiribati are most vulnerable to the impacts of climate change which include accelerated sea-level rise. This is because of their small sizes, low lying topography, limited resource endowment, and also because Kiribati is a least developed country.” (NC p.30)

- The literature is in agreement that Kiribati is experiencing a current sea level rise of 4 mm per year, which if it continues, will reach 10 cm by 2025.
- The population growth rate has decreased from 2.26% (1985-90) to 1.42% (1990-95). However, until it can level off, the growing population will put increasing pressure on the islands resources and government services.

“Examples of inequitable vulnerability to coastal hazards include population shifts in Pacific island nations such as Tonga and Kiribati.” (IPCC p.366)

“Each of the inhabited atoll is an ecosystem on its own. No two atolls are similar, except for their general features of being small in land area, generally flat with the land surface at any height from less than a meter to about 4 meters above the sea level. Yet vulnerability assessment studies that have been carried out were limited to few areas of South Tarawa. The results would therefore be generalised to all atolls, but significant differences in the case of any other atolls would also be pointed out.” (NC p.33-34)

#### ***Water Resources***

- Water lenses appear to be more sensitive to the amount of rainfall and the width of the island, rather than to a rise in the sea level.
- Sea level rise will raise the water lens but without any significant change in the depth of freshwater limit. “A 50 cm rise in sea level would raise the water table by approximately the same amount so it was thought there could be a slight increase in the thickness of the freshwater lens. A 1 m rise would most likely cause inundation of the island near the sea. The combined impact of a rise of 1 meter in sea level, erosion by 12.3%, and current rainfall would be 10% reduction in the water lens.” (NC p.34)
- Limited freshwater lenses exist on all of the inhabited atolls except on Banaba.

“With the sea-level rise scenarios, it would be most likely that a pattern of erosion and accretion would evolve that could change the distribution of ground water lenses. There are no scenarios established for rainfall. It is however probable that rainfall may not change but that its intensity could increase, in which case land coastal erosion from rainfall would be exacerbated.” (NC p.34)

- Intense rainfall would tend to improve the quality of the ground water lens within the atolls.

“There could be problems when the water lens gets very close to the land surface.” (NC p.34)

#### Human Health

- In 1999, the rains came late in April and May, but when they did come, widespread diarrhoea struck South Tarawa. If the freshwater lens rises with the sea level rise and causes inundation, impacts on the health of the people would be anticipated.

“Drinking water from wells can be contaminated through leaching of pollutants, runoff from nearby ground during raining periods, and salt intrusion from salt water underneath the water lens. Sources of pollution are the wastes on the land, coastal areas and the sea. Guidelines on how to protect wells should be developed and widely distributed; the wells should additionally be monitored for quality.” (NC p.38)

“Spring tides could also contaminate ground water lenses for it is common knowledge that at the onset of spring tides, babies would normally contract diarrhoea.” (NC p.38)

“In the dry season, the range of the vectors could be wider. People are also more mobile. With the impossibility of getting rid of all the nesting places of these vectors, any disease that struck the atolls may spread more rapidly in the dry season, for example dengue fever.” (NC p.38)

- Changes in rainfall from the traditionally dry (Aumaiaki) and wet (Aumeang) seasons would affect the incidences of the vector and waterborne diseases.

“Increasing trend in temperature has been observed from the observing stations in Kiribati. The trend has been very small, but even then some older people thought that they have felt this change. However, heat waves could not occur in the atolls but the glaring sun could damage eyesight, accelerate aging processes, and reduce the general health and productivity of the people.” (NC p.38)

#### Coastal Areas

“There is no hinterland on atolls, and the coastal area is evidently the whole of the atolls.” (NC p.35)

“Throughout South Tarawa, a complex pattern of erosion and accretion has been occurring. As a result, individual islets and any stretch of land would either have gained or lost in area.” (NC p.35)

“Overtopping from storm surges has regularly occurred in some parts along the shore of Betio, even in areas where there are seawalls. Overtopping destroys breadfruit trees, and a few other fruit trees that may grow on the coastal area. However, storm surges need not necessarily result in erosion. But complex patterns of change in land formation would most likely occur; nonetheless such a scenario is equally destructive and costly to any atoll, since the land area is very small and options for land utilisation are constrained by that fact.” (NC p.35)



- Climate change may also cause an increase frequency of El Nino and La Nina events.

“A drought from May 1998 to late March 1999, concurrent with the La Nina conditions, seriously affected Kiribati. Coconut trees, and breadfruit trees were dying particularly in South Tarawa but also on outer islands. An informant recollected that the drought in 1930s involved a longer period without rain....Resilience of trees to drought conditions may have decreased, which might suggest that evapotranspiration might have already been stressful for trees. Positive linear trends in surface temperature records from observing stations in Kiribati have been demonstrated.” (NC p.35)

#### Agriculture

- Important tree crops include coconut trees (*Cocos nucifera*), pandanus trees (*Pandanus tectorius*), giant taro (*Cyrtospermachamissionis*), breadfruit (*Artocarpus sp.*), and banana (*Musea sp.*) on the northern atolls.

“With abundant fish, these trees support the subsistence life style of the people.” (NC p.36)

- Needless to say, climate change and sea level rise would have major impacts on the agricultural sector.
- In some parts of South Tarawa and other atolls, aged coconut trees (used by the locals to mark boundaries and subsistence living) had been uprooted in the process of coastal erosion.
- There was an unsuccessful coconut tree replanting scheme in the late 1960s based on the assumption that coconut trees grow better and are more productive if near the water lens.
- However, coconut trees appear to do better in drier soils, like those found in the South as opposed to the damper soils of the north.
- Rising sea levels might therefore decrease coconut production by increasing soil moisture.
- The varieties of pandanus trees are specific to the different atolls. “An attempt to disseminate these varieties to atolls where they are not found proved unsuccessful, implying that small differentials in the climate between atolls exist and that these trees are sensitive to such small differentials in the amount of rainfall, and temperature.” (NC p.37)
- Giant taro are planted in dug out pits reaching the water lens. They may also be adversely affected. “It is known that where the pit is within a thin water lens, uprooting a giant taro causes the infiltration or the “upwelling” of salt water into the pit. In the northern Gilbert many large pits (a few acres) are owned by a number of families, and these pits would be affected by the sea-level rise.” (NC p.37)

“Some islets in Tarawa are disappearing, and with drought and sea-level rise the vegetation structure is changing. Coconut trees along the “coastal” area (mataniwin te aba) withered and died while undergrowths of salt bush (*Scaevola sericea*), beach heliotrope (*Tournefortia argentia*), beach mulberry (*Morinda citrifolia*), and varieties of low grasses were succeeding them.” (NC p.37)

- Sea level rise would cause changes in erosion and accretion patterns which would also lead to the succession of different tree and plant species. “Human intervention would be directed to the planting of the traditionally more valuable trees in newly accreted land, but might not be extended to planting other trees and plants as a conscious effort to protect coastal and land erosion.” (NC p.37)
- Mangroves may also be affected.

Traditional management of the long-term tree crops is being encouraged by the government, “but this is facing the challenge from the changing value system about agriculture arising

from some level of modernization taking place in the country. Short-term cash earning from copra and other products of the coconut trees, pandanus trees, and other plants are preferred to the sustainability of the land productivity. Pandanus trees might receive increasingly less attention, yet this is an important tree for local construction and home amenities.” (NC p.37)

#### Marine ecosystems

- In the 1990s, changes in the El Nino and La Nina events shifted Skipjack Tuna populations eastward towards Kiribati. Skipjack tuna “dominates the world’s catch of tuna”.
- The corals reefs are affected by sea temperature, depth below sea surface, and amount of sunlight.

“Corals have a crucial role in determining the vulnerability of the atolls to the adverse impacts of climate change and the rise in sea level.” (NC p.39)

“Structural changes in the coast have been attributed as a major cause of erosion. However for South Tarawa we estimated that about 19% of the shoreline has been modified by engineering structures including sea walls, wharves, and causeways. There has been negligible modification of coastal areas of some outer islands, yet they too have serious coastal erosion problems.” (NC p.39)

#### **Current or Recommended Strategies for Climate Change Adaptation**

- At the time that the NC was written the Kiribati government was processing an environmental Bill through parliament, which included an Environmental Impact Assessment process and pollution controls.
- Programs to increase people’s awareness of their environment and climate change issues.

#### Water Resources

- Piped water systems should be upgraded and the system should be extended to cover people who are not served.
- Meters should be used.
- Owners of any building with permanent roofing should be encouraged to install and build rain water storage for the building.
- Private wells in urban Tarawa should be regularly tested and monitored for biological and chemical pollution, and owners advised of the quality of the water and of steps to improve and maintain quality standard.

#### Human Health

- The use of traditional medicines should be facilitated.

#### Coastal Zones

- Avoid development in areas that are vulnerable to inundation;
- Strategies advocated are: retreat; accommodation; and protection.
- A Coastal Zone Management Plan should be developed.
- Protection of important public infrastructure should be planned, including seawall construction.
- Concrete should be used instead of coral boulders in construction.
- Planting of mangroves around the coast.

#### Agriculture

“Traditional agricultural systems should be revived, including a re-evaluation of traditional value systems on products and uses of trees and plants. Economic agricultural policies such as subsidies should be re-appraised as they could insidiously undermine Kiribati culture and the traditional value system underlying agricultural systems.” (NC p.42)

“Rice, flour, sugar, and even tinned fish have become the preferred diet of Kiribati people. Whilst in urban South Tarawa, this is explained by the dominating cash economy, the situation in rural areas is different. The prices of rice, flour, and sugar are controlled and this could encourage low price and higher consumption. There may be a need to consider appropriate disincentive policies on consumption of flour and rice and for incentive policies to promote local food.” (NC p.42)

Marine Ecosystems

- There is no effective management system in place to protect the marine and intertidal ecosystems especially corals, sea grasses, fish, sediments and aggregates.
- “One adaptation option is to re-establish a traditional system of ownership and specific rights on coastal areas, including reef patches and shoals. This option appears to be supported with some qualifications in a workshop conducted on seven rural atolls of Kiribati.” (NC p.42)
- Removal of materials from the foreshores could be controlled through legislation.

Data from UNCTAD, IPCC and Kiribati’s initial National Communications, completed in September of 1999.

**Samoa**



**Statistics**

Population	0.2 million
GNP per capita	US \$1,070

**Percentage share of GNP**

Agriculture and livestock	unknown
Industry	unknown
Services	unknown
Gross Domestic Investment	unknown
Main Export	Travel (47.4% of total export)

- High rainfall and humidity.
- Temperatures are uniformly high throughout the year.
- Severe tropical cyclones occur during the summer, from December to February.
- “Samoa is also vulnerable to anonymously long dry spells that coincide with the El Nino Southern Oscillation...” (NC p.v)

**Vulnerabilities to Climate Change**

- 70% of the population and infrastructure is located in the low-lying coastal areas, and is therefore vulnerable to climate change and sea level rise.
- “the increasingly frequent intense cyclones affecting Samoa are a major threat to its sustainability in the modern world and global economy; the ‘best guess’ scenarios

indicate that by the year 2100, temperature will have increased 2°C, with SLR of 49 cm, and a rainfall increase of 4.1%.” (NC p.viii)

“Increased heat stress on organisms and altered water requirements for various species are also associated with climate change and SLR. This would severely stress Samoa’s uniquely adapted biodiversity and thus necessitate further adaptation for alien and potentially invasive species.” (NC p.viii)

- Land clearing today is for timber and not agriculture.
- Poor management has led to severe soil erosion and the increased use of chemical fertilizers threatens water catchments and water supplies.
- The Scengen model predicted an increasing trend for precipitation, with an increase of 2.2% by 2050 and 4.1% by 2100. The HADCM2 IS91a model predicts an increase of 3.7% by 2050 and 6.8% by 2100.
- Samoa will most likely be affected by more cyclones in the future.
- By 2100, the population of Samoa is likely to increase to 1.3 million, which will place a greater demand on the biophysical environment.

#### Human Health

- Population at risk from dengue fever, gastroenteritis, and diarrhoea (the later two caused by flooding and poor water sanitation).
- SLR is expected to bring more flooding, which will increase waterborne diseases. A temperature increase of 2°C will lead to greater heat stress the proliferation of vector borne diseases.

#### Water Resources

- Samoa receives a large amount of water and so has adequate ground and surface water resources.
- However, “[p]rolonged drought spells in the recent past have highlighted Samoa’s vulnerability to the potential increase of drought conditions through global warming. Stringent measures were put in place during the dry spell to ensure all households received some water everyday.” (NC p.28)

#### Agriculture

- Main crops are coconuts, cocoa, kava, bananas, giant taro, yam and taro.
- Increased precipitation will lead to greater soil erosion and rain run-off.
- It is thought that a temperature increase of 2°C would shift crop production to higher elevations, but the steep slopes are only viable for timber production and not crops such as coconuts.
- Increasing evapotranspiration due to higher temperatures would offset increased rainfall of 4%.

“The higher night temperatures, in particular, has been reported to increase respiration from soils...which would reduce soil organic matter and soil fertility. Higher rainfall would also increase the loss of soil nutrients due to leaching, especially with the decreased protection of soil organic matter.” (NC p.32)

#### **Current or Recommended Strategies for Climate Change Adaptation**

- Adaptation measures need to be focused on coastal areas where 70% of the population lives.
- The government has already identified 12 priority areas for climate change and SLR.
- The government now wishes to build a seawall.
- The government has proposed a township at Salelologa, on the island of Savaii, to redistribute some of the population.

- “Drought tolerant pastures, e.g. *Panicum maximum* varieties, of guinea/green panic grasses have been recommended.” (NC p.32)
- “Likewise, drought intolerant Hereford cattle have already been cross-bred with Brahman to no more than one-eighth Hereford, and Droughtmaster cattle breed has also been introduced.” (NC p.32)

#### Coastal Environments

- Devise a suitable integrated coastal zone management plan.
- Plant more trees, e.g. coconut on the coastline to prevent soil loss.
- Conduct public awareness programmes targeting the general audience on issues of reef and lagoon rehabilitation.
- Build houses more suitable to climate change.
- Initiate and increase government assistance programmes for coastal areas.
- Discourage reclamation practices.

#### Human Health

- Health education and awareness at the community level.
- Regular cleaning campaigns for sites where mosquito vectors are abundant.
- Conduct research programmes on the use of biological control.
- Encourage development of proper waste disposal methods.
- A reliable and safe drinking water supply.

#### The Water Sector

- Community involvement in the establishment of better water management practices.
- Establish new catchments areas for conservation.
- Land-use planning to control deforestation.
- Improve and maintain water supply infrastructure such as water tanks and pipes.
- Increase the number of water treatment plants.

#### Agriculture

- Quarantine surveillance should be increased for alien/invasive species.
- Crop and livestock varieties must be better adapted to extreme temperature and extreme events.
- Agro-forestry/agro-silvo-pastoral systems may be used to reduce erosion and run-off on steep slopes.

#### Biodiversity

- Community based forest conservation projects should be encouraged in remaining natural forests.
- Conduct research into more sustainable social-economic practices.
- Development appropriate legislation and policies for conservation of forest resources, like mangrove forests.
- Research tree species that are faster growing and resistant to disease and fire.
- Encourage conducting EIAs for any major development.

*Data from UNCTAD, IPCC and Samoa's initial National Communications.*

### Solomon Islands



#### **Statistics**

Population	0.4 million
GNP per capita	US \$760

#### **Percentage share of GNP**

Agriculture and livestock	unknown
Industry	unknown
Services	unknown
Gross Domestic Investment	unknown
Main Export	Timber products (42.7% of total export)

#### **Vulnerabilities to Climate Change**

##### Biodiversity

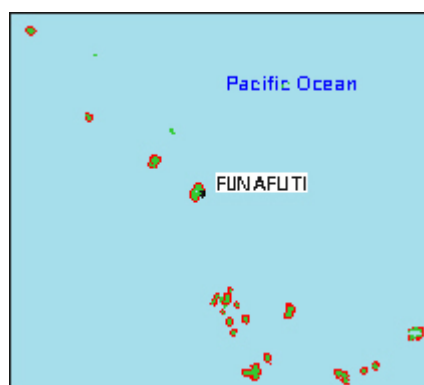
- There are 53 known mammals on the islands, 19 endemic mammal species, 223 known bird species, 44 known endemic bird species, 2,780 known plant species, 30 of which are endemic.

##### Tourism

Among the small island states the Solomon Islands have relatively few tourists, averaged at about 16,000 per year (in 1997), which made up 3.7% of the population and contributed to 2.8% of the GNP and 4.2% of exports.

*Data from UNCTAD and IPCC.*

### Tuvalu



#### **Statistics**

Population	11 million
GNP per capita	unknown

### **Percentage share of GNP**

Agriculture and livestock	unknown
Industry	unknown
Services	unknown
Gross Domestic Investment	unknown
Main Export	Travel (29.5% of total export)

### **Vulnerabilities to Climate Change**

- Rising sea levels, increased temperatures, increased frequency of drought, strong winds, floods and storms, coastal erosion, and threats to fresh water supply.

“The islands of Tuvalu are only a few meters above seal level. Any rise in sea level will have serious impacts on human health, houses, infrastructure, food crops, ground water sources, land and marine biodiversity, vegetation and the shoreline.” (NC p.10)

### Water Resources

- Salt water intrusion into wells, increased water shortages since many wells may have to be closed, and health problems related to water shortages.

### Agriculture

- Decline in crop production due to salination and increased transpiration.
- “There is the expected emergence of new agricultural pests.” (NC p.10)
- Reduced food production due to decrease in water supply.
- Increased soil erosion due to the increased frequency of cyclones under climate change.
- Sea level rise reducing the amount of land available for crops.
- Subsistence crop yields may improve under warmer conditions, however others like the pulaka do not due well with increased salination.
- “Droughts will be more frequent causing low yields.” (NC p.14)

### Wildlife and Biodiversity

- Coral bleaching under rising temperatures, which in turn will affect shellfish and fish population.
- Algal blooms associated with climate change will have a negative effect on water resources and wildlife.

### Human Health

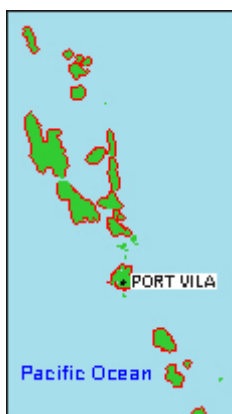
- Increase in mosquito vector diseases.

### **Current or Recommended Strategies for Climate Change Adaptation**

- Protection of usable (fresh) groundwater resources and an increased catchment of rainwater.
- Development of the existing Funafuti Conservation Area into a representative network of conservation areas with at least one on each of the nine islands, and with improved public awareness and enforcement.
- Development of a national population strategy.
- Improvements in subsistence agriculture, and methods of food production and handling, which have fewer environmental impacts.
- Improved coastal management to protect against soil erosion and a shift towards restoration of the original ecosystems rather than seawalls and other structures.
- Real options for renewable energy.

*Data from UNCTAD, IPCC and the initial National Communications.*

## Vanuatu



### **Statistics**

Population	0.2 million
GNP per capita	US \$1,260

### **Percentage share of GNP**

Agriculture and livestock	24.7%
Industry	12.2%
Services	63.2%
Gross Domestic Investment	unknown
Main Export	Travel (33.9% of total export)

### **Vulnerabilities to Climate Change**

- Climate scenarios generated using SCENGEN, as well as two global circulation models: HADCM2 and CSIRO9M2.
- The HADCM2 model predicted a temperature increase of 1.4°C to 2.2°C by 2050 and between 2.4°C and 4.5°C by 2100, and a precipitation decrease of 6.8 to 10.6% by 2050, and between 11.8 to 22% by 2100.
- The CSIRO9M2 model predicted a temperature increase between 0.9°C to 1.5°C by 2050, and between 1.5°C to 3.0°C by 2100, and a precipitation increase of 7.4% and 12.1% by 2050, and between 13.5% and 25.2% by 2100.
- Sea level is expected to rise between 19.8 to 39.7 cm by 2050, and between 48.9 to 94.1 cm by 2100.

### Agriculture

- Generally it is thought that an increase in atmospheric CO<sub>2</sub> concentrations and warmer temperatures will promote rapid growth of green matter rather than crops.
- “Crop growth seasons are likely to change” and “[p]astures may support fewer animals as the more rapid growth as expected may lead to grasses of less nutritious value than at present.” (NC p.28)
- Both commercial and subsistence agriculture are based on rain-fed agricultural production systems. Therefore, changes in precipitation patterns will disrupt production.
- There may also be an increased frequency of storm events.
- “Intense rainfall in planting seasons could damage seedlings, reduce growth and provide conditions that promote pests and diseases. More pronounced dry seasons, warmer temperatures and greater evaporation could stress plants reducing productivity and harvests.” (NC p.28)

### Human Health

- Mosquito borne diseases are widespread in Vanuatu.



- Both climate scenarios used in the NC provide conditions that would “sustain breeding sites for mosquitoes and potentially extend breeding seasons”. (NC p.28) This in turn would increase the spread of diseases like malaria, dengue, and filiarisis.
- Increased rainfall and cyclones would also bring favourable conditions for waterborne diseases.

#### Water Resources

- The country has limited surface water and many islands depend on ground water.
- “Increased temperatures are likely to increase the demand for potable water.” (NC p.29)
- “However, increased heat, greater run-off from high intensity rainfall events, decreased rainfall and an associated increase in evaporation could reduce the rate of ground water recharge and decrease surface water flows.” (NC p.29)
- Salt water intrusion with a rise in sea levels would be most detrimental in the small low-lying islands that are dependent on shallow ground water aquifers.

#### Coastal Environment

- Many major areas of importance will be threatened with a rise in sea levels such as the low lying islands of the Torres Group, Mele on Efate island, and east-Ambae.

#### Coral Reefs

“They are important sources of economic and subsistence resources, and a draw-card for the important tourism sector, while protecting adjacent coastlines from extreme sea events.” (NC p.29)

- Highly vulnerable to rising temperatures and increased cyclone events.

#### Fisheries

“Any rise in sea surface temperature is likely to decrease the amount of available oxygen, increase the growth of aquatic plants and increase the metabolic rates of organisms. The decrease in available oxygen is likely to reduce growth, lower survival rates and increase fish mortality.” (NC p.30)

“Changes in sea temperatures will lead to changes in wind and ocean circulation patterns that may impact on the distribution and availability of nutrients and change patterns of migratory and non-migratory fish stocks.” (NC p.30)

“Greater extremes of weather may reduce opportunities for fishing during some seasons. Greater extremes of weather may also affect transport services between islands reducing opportunities to market produce.” (NC p.30)

### **Current or Recommended Strategies for Climate Change Adaptation**

#### Agriculture

- Diversification of crops, both commercial and subsistence.
- Develop a better understanding of the horticulture of subsistence food crops, especially in relation to pest control, to enable to better selection of crops. Crops of particular interest include yam, taro, manioc, kumara, banana, and island cabbage.
- Rural families do not purchase seed but select their seed from one year’s plantings, which they store and plant in the following growing season. This strengthens the capacity of agriculture to gradually adapt to climate change.

#### Human Health

- Further development and expansion of public awareness and malaria campaigns, especially on the smaller islands such as Tongoa.

- Promotion of hygienic waste disposal methods to prevent water contamination after cyclones and floods. Management of surface water catchments in order to help maintain the quality and continuity of domestic water supplies.

#### Water Resources

- Better management of water catchments “so as to maintain water quality and maximize groundwater recharge, will minimize climate change impacts on water resources while providing immediate human benefits in areas that already suffer seasonal shortages, and help to maintain environmental quality.” (NC p.34)
- Improved management and maintenance of water supply networks to reduce wastage. This will require training in taps, tanks and pipes, and access to appropriate hand tools.
- Initiatives that promote water conservation and moderate usage, and raise public awareness.

“Introduction of policies to extract freshwater from coastal aquifers only where there are no feasible alternatives would reduce the vulnerability of coastal communities and reduce the need to replace infrastructure should salt water intrusion occur.” (NC p.34)

- Expansion of rainwater storage capacity, frequently through installation of water tanks will reduce the vulnerability of communities in times of water shortage.” (NC p34)

#### Coastal Development

“Modelling the storm surge zone, taking into consideration possible sea level rises, provides a powerful tool for reducing vulnerability. Planning mechanisms can be used to direct all new investments in infrastructure, housing construction and agriculture outside this zone to minimize vulnerability, reduce repair costs and decrease disruption to economic activities.” (NC p.34)

- Future developments in infrastructure engineered to withstand cyclones, floods and intense rainfall.
- “Exclusion of extraction activities from the coastal zone, including sand extraction and mangrove enables these areas to provide a protective buffer from impacts of coastal erosion. Replanting littoral vegetation in cleared or degraded areas would restore their coastal protection benefits.” (NC p.34)
- Disaster planners to help communities prepare for “worst-case” scenarios.

*Data from UNCTAD, IPCC and the initial National Communications.*

This paper is part of the following series:

**MAINSTREAMING ADAPTATION TO CLIMATE CHANGE IN LEAST DEVELOPED COUNTRIES (LDCS)**

Saleemul Huq, Atiq Rahman, Mama Konate, Youba Sokona and Hannah Reid  
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The Least Developed Countries (LDCs) are a group of 49 of the world's poorest countries. They have contributed least to the emission of greenhouse gases but they are most vulnerable to the effects of climate change and have the least capacity to adapt to these changes. Adaptation to climate change has become an important policy priority in the international negotiations on climate change in recent years. However, it has yet to become a major policy issue within the developing countries, especially the LDCs. The experience cited in this report of two LDC countries, namely Bangladesh in Asia and Mali in Africa, shows that although much has been achieved in terms of describing and analysing vulnerability to climate change and identifying potential adaptation options, there remains much more to be done in terms of mainstreaming adaptation to climate change within the national policy making processes in those countries.

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