

A NATION UNDER THREAT

The impacts of climate change on human rights and forced migration in Bangladesh



The Environmental Justice Foundation (EJF) is a UK-based charity (No. 1088128) working internationally to protect the environment and defend human rights.

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**THERE’S NO PLACE LIKE HOME –
campaigning for environmental security
and human rights**

Each year, millions of people are forced from their homes and land by climate-related, natural disasters. Some of these people are displaced by sudden onset storms and flooding, others by longer term hazards like drought and desertification. Most are from the world’s poorest and most vulnerable countries. Many face an uncertain future, with nowhere to go and no means to survive. EJF works to raise awareness and improve the well-being and welfare of these climate refugees. We campaign for a new, legally-binding instrument for their legal recognition, protection and assistance.

Help us get their voices heard

EJF’s Home Truths – the Climate Witness Network is working to connect people around the world, empowering them to start a dynamic conversation on climate change, providing a platform where people can share their thoughts, ideas and hopes. EJF is helping individuals and communities to document the issues that affect them, using photography and film to show what it is like to live on the frontline of climate change.

To support our work, get involved today by visiting www.ejfoundation.org

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UN Cartographic Section

Executive summary

- This report considers the human impacts of climate change in Bangladesh through the perspective of vulnerable communities, whose testimonies were documented by EJF. It provides evidence that climate change poses a severe and, at times, immediate threat to human rights and that intervention is urgently required.
- Human activities have released vast quantities of greenhouse gases (GHGs) into the atmosphere, exacerbating natural processes and resulting in dramatic changes to the environment and climate. These changes, and the consequent decline in environmental conditions, are having a highly profound human impact. While no country will be spared from the impacts of climate change, severe effects will be disproportionately felt by many of the world's poorest regions, countries and people. These are the places and populations which have typically contributed the least to climate change.
- Bangladesh is considered to be one of the most vulnerable countries to climate change. This stems from its extremely high population density, limited natural resources, dependence on agriculture, geography and high incidence of natural disasters.
- With around half of the Bangladesh labour force engaged in farming, and with few other livelihood options, the negative impacts of climate change on agriculture – namely variations in rainfall and temperature – have serious implications for food security, hunger and poverty. Unpredictable seasons mean that traditional farming practices are failing communities and rural livelihoods are collapsing.
- Poverty in Bangladesh has pushed people into marginal, hazard-prone land and many millions are living in areas at 'high risk' of natural hazards including river erosion, cyclones and flooding. Declining environmental conditions deny many millions of people their right to adequate housing and shelter.
- Where there is a direct and immediate threat to life or where environmental pressures compound socio-economic stresses



Storm damage to flood defences means that this riverside village floods daily

- and households cannot adapt, families are being forced to abandon their homes and land. These 'climate refugees' face an uncertain future, without legal recognition and largely unaided beyond immediate disaster relief.
- It is evident from this study that a more sophisticated and coordinated international response and actions are needed. The international community needs to use a human rights lens to deliver an adequate strategic approach for action to address both the causes and consequences of climate change. In addition to much greater, urgent action to mitigate climate change, EJF strongly advocates substantial and immediate financial, logistical and technical assistance for adaptation to those first and worst affected by climate change and a new, legally-binding instrument for the recognition, protection and assistance of climate refugees.

“We went home [after the cyclone had passed] and saw that there was nothing left. There wasn’t a single house that you could live in. Only the houses built around trees, somehow their structure was still there, but they were unlivable. All the mud houses, clay houses were completely gone.”

Ataur Rahman, former resident of Patuakhali¹



© EJF

Introduction



People left stranded on an eroded road on Bhola Island
© 2005 Gary Braasch / www.worldviewofglobalwarming.org

“Climate change is a completely different phenomenon altogether and it is going to add to already existing problems. The world community needs to think about having a new set of legislation to deal with the problem, to deal with refugees that will actually be induced by the factors of climate change.”

Rizwana Hasan, Bangladesh Environmental Lawyers Association (BELA)²

Climate change amplifies existing social, environmental, economic and political stresses and creates new ones. Its 'multiplier effect' will push some of the world's poorest and most vulnerable people deeper into poverty, while strains on national and international governance are amplified and progress on development is obstructed. A large proportion of the planet's population already lives in conditions where they are denied many basic human rights. Projections of climate change indicate that this will increase as food and water security decline, homes are damaged or destroyed by extreme weather events and more lives are threatened³.

Low-lying, coastal developing countries and Small Island Developing States (SIDS) are likely to be most acutely affected by declining environmental conditions associated with climate change, despite the fact that most have contributed the least through their greenhouse gas (GHG) emissions. Bangladesh is an oft-cited example of a country in this position; widely recognized as one of the most vulnerable countries to climate change because of its high exposure to the negative impacts of climate change and its pre-existing, socio-economic vulnerabilities.

This report provides an overview of some of the core challenges Bangladesh faces as a result of climate change, exemplified by testimonies from individuals and communities feeling its effects, gathered by EJF during a field investigation. In particular, it highlights the risks posed to water and food security, health and rural livelihoods and the need for action on climate change.

More than two decades ago, the Intergovernmental Panel on Climate Change (IPCC) suggested that the gravest effects of climate change may be those on migration⁴. Today, it is widely accepted that it will affect migration now and in the future. The testimonies presented in this report indicate that there is a strong relationship between environmental change and migration in Bangladesh, and that in many circumstances this migration is forced rather than voluntary, precipitated by severe and immediate threats to environmental security and human rights. On this basis, we can determine that these people are, in effect, 'climate refugees'.

The findings of this report highlight how the international community has neither planned nor prepared adequately for the impacts that are already resulting from a failure to mitigate climate change and to facilitate adaptation to its effects. Through this human rights-based analysis it is evident that collaboration and action on climate change are urgently needed. Those countries most severely affected, like Bangladesh, need financial, logistical and technical support. In addressing the impacts of climate change and forced migration, the international community must support a new, legally-binding agreement to recognize, protect and assist climate refugees.

The human impacts of climate change

The fifty Least Developed Countries (LDCs) are responsible for less than 1% of global CO₂ emissions

Scientific records show that rainfall patterns are changing, surface air temperatures are rising and extreme weather events are becoming more intense. Increasingly large areas are being affected by more frequent and longer-lasting droughts and desertification. Crucial freshwater sources are being contaminated by saltwater intrusion, and soils are being rendered infertile by salinisation. Oceans are becoming warmer, more acidic and sea levels are rising. The climate is naturally dynamic and environmental conditions have changed dramatically throughout the planet’s history, however, the changes observed in the past few hundred years do not fit the background levels of change and are very likely the result of human activities⁶.

Greenhouse gases (GHGs) such as carbon dioxide (CO₂) and methane (CH₄) form an insulating layer in the atmosphere, trapping heat from the sun, and making the planet inhabitable (the ‘greenhouse effect’). These gases occur naturally but are also emitted by human activities, in particular the burning of fossil fuels, deforestation and intensive agricultural practices. Human activities have released 900 billion tonnes of carbon dioxide (CO₂) into the atmosphere since pre-industrial times⁷. Atmospheric concentrations of CO₂ and CH₄ today greatly exceed the natural range over the last 650,000 years⁶, and the overall trend is an increase of GHG emissions. This has had the effect of exacerbating natural processes, resulting in marked anthropogenic (human driven) changes to the global environment and climate and, in turn, impacting heavily on people.

“We must not lose sight of existing human rights principles in the tug and push of international climate change negotiations. A human rights lens reminds us there are reasons beyond economics and enlightened self-interest for states to act on climate change.”

Mary Robinson, former Irish President and former UN High Commissioner for Human Rights⁵



Flooding in Bangladesh in 1991

© USAF

An issue of environmental justice

“Climate change-related impacts have a range of implications, both direct and indirect, for the effective enjoyment of human rights including, inter alia, the right to life, the right to adequate food, the right to the highest attainable standard of health, the right to adequate housing, the right to self-determination and human rights obligations related to access to safe drinking water and sanitation, and recalling that in no case may a people be deprived of its own means of subsistence.”

Human Rights Council Resolution 10/4
‘Human rights and climate change’

Climate change is an issue of common but differentiated responsibility as countries differ dramatically in their historical and contemporary GHG emissions. The most recent data on emissions (current at the time of going to print) is from 2009, and this data shows that there was more than a 137 million percent difference between the total CO₂ emissions of the countries with the highest and lowest emissions⁸. China, the USA and the EU (27 member states) together produce more than half of the world’s CO₂ emissions. Meanwhile, the fifty Least Developed Countries (LDCs) are responsible for less than one percent of global CO₂ emissions⁹.

Although no country will be insulated from the impacts of climate change, many LDCs are disproportionately vulnerable due to their relatively high exposure to the negative impacts of climate change and their limited adaptive capacity. Most at risk are those that are low-lying or coastal, small islands or arid countries liable to flooding, drought and desertification, and those with fragile mountainous ecosystems. Simply put, those who are least culpable for climate change are feeling its first and worst effects.

The total and per capita CO ₂ emissions of the 10 countries considered to be most vulnerable to climate change		
Country~	Total CO ₂ emissions, world rank*	CO ₂ emissions per capita, world rank*
1. Haiti	152	192
2. Bangladesh	57	181
3. Sierra Leone	163	189
4. Zimbabwe	100	157
5. Madagascar	138	198
6. Cambodia	134	188
7. Mozambique	149	203
8. Democratic Republic of the Congo	146	214
9. Malawi	166	207
10. Philippines	47	167
<small>~ World rank out of 193 countries, according to Maplecroft Climate Change Vulnerability Index (2012) - http://maplecroft.com/about/news/ccvi_2012.html * World rank out of 218 countries, according to US Energy Information Administration, International Energy Statistics (2009) - http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8&cid=regions&syid=2005&eyid=2009&unit=MTCDPP</small>		

Bangladesh – victim of climate change

“Though our share of carbon gas emissions is negligible, we are its worst victim.”

Sheikh Hasina, Prime Minister of Bangladesh¹⁰

Bangladesh is a country that stands to be disproportionately affected by climate change. Its vulnerability stems from the combination of its extremely high population density, low resource base, principally agrarian economy, geography and high incidence of natural disasters¹¹. Bangladesh does not have the capacity to fully protect and assist its population without international support. It is home to an estimated 2.2 percent of the world’s population¹², approximately 80 percent of whom live on less than US\$2.00 a day and half of whom live on less than US\$1.25¹³. The impacts of climate change will weigh particularly heavily on this sector of the population.

Bangladesh is a strategically important emerging economy. It has achieved significant progress towards a number of development targets laid out in the Millennium Development Goals (MDGs). In particular, it has experienced successes in the areas of primary schooling, gender parity in primary and secondary level education, lowering the under-five mortality rate, reducing the incidence of communicable diseases and improving indicators on environmental changes¹⁴. However, it is still a significant distance from other social, economic and environmental targets, and climate change represents a significant obstacle to the future development of the whole country¹⁵.

Projected impacts of climate change in Bangladesh		
Climate and related elements	Critical vulnerable areas	Impacts
Temperature rise and drought	North West region	<ul style="list-style-type: none">• Agriculture (crops, livestock, fisheries)• Water• Energy• Health
Sea level rise and saline intrusion	Coastal areas Islands	<ul style="list-style-type: none">• Agriculture (crops, livestock, fisheries)• Water (water logging, drinking water, urban)• Human settlements• Energy• Health
Floods	Central region North East region Chars	<ul style="list-style-type: none">• Agriculture (crops, livestock, fisheries)• Water (urban, industry)• Infrastructure• Human settlements• Health• Energy
Cyclones and storm surges	Coastal and marine zone	<ul style="list-style-type: none">• Marine fisheries• Infrastructure• Human settlements• Life
Drainage congestion	Coastal areas Urban areas South West region	<ul style="list-style-type: none">• Water (navigation)• Agriculture (crops)
Source: Ministry of Environment and Forests, Government of the People’s Republic of Bangladesh (2005) National Adaptation Programme of Action (NAPA) for the UNFCCC		



BANGLADESH – key statistics	
Area (km ²)	143,989 ¹⁶
Population, 2010	164.4 million ¹⁷
Population growth rate (%), 1970-1990	2.6 ¹⁸
Population growth rate (%), 2010-2015	1.3 ¹⁸
Urban population (%), 2010	28 ¹⁸
Gross Domestic Product (GDP) (equiv. million US\$), 2010	90,036 ¹⁹
Gross National Income (GNI) per capita (PPP\$), 2008	1,440 ¹⁸
Value of remittances (millions US\$), 2010	10,987 ²⁰
Official Development Assistance (ODA) inflow (millions US\$), 2008	2,061 ²¹
Human Development Index (world rank), 2011	146 ²²
Climate Change Vulnerability Index (CCVI) (world rank), 2012	2 ²³

Dhaka is one of the world’s largest megacities ©EJF

Exacerbating poverty and hunger

Experts estimate that, within a given area, crop losses caused by a cyclone will result in an equivalent percentage increase in poverty in Bangladesh²⁴

Agriculture is the most important economic sector in Bangladesh: it employs around half of the country’s labour force²⁵, the vast majority working at subsistence level or as small-scale farmers²⁶. In some rural areas farming is the only livelihood option. The rural economy constitutes a significant component of the national Gross Domestic Product (GDP), with agriculture (including crops, livestock, fisheries and forestry) accounting for in excess of 21 percent^{26/27}. Most other economic sectors or activities are dependent on it, either processing its products or servicing the sector²⁸.

The agricultural sector faces a number of core challenges, including limited land availability for farming, lack of and poor quality of rural infrastructure and services, vulnerability to natural disasters, weak rural financial systems and intense rural poverty²⁷. The rising temperatures, changes to rainfall and increasingly intense extreme weather events associated with climate change already exacerbate many of these underlying vulnerabilities, with increasing risks to crop yields, livestock, infrastructure and assets like machinery.



With half the labour force employed in agriculture, Bangladesh’s economy is extremely vulnerable to environmental change © EJF

More intense extreme weather events would have a significant impact on poverty and hunger in Bangladesh. This is clear from past disasters, such as the 1998 floods during which 45 out of the country’s 64 districts were inundated and more than two million tonnes of rice crops were destroyed²⁹. Crop and livestock losses and land degradation resulted in at least one in 13 people from affected areas being forced to change their occupation, and nearly one third of the affected population was left unemployed³⁰. Food consumption fell during the floods, with calorie consumption of flood-exposed households on average 272 calories per person per day lower than that of households not exposed to flooding. Significant food insecurity resulted and stunted growth amongst pre-school children increased²⁹.

Open water ecosystems in Bangladesh have been “seriously degraded” not only as a result of pollution, land use changes and mismanagement but also the already visible impacts of climate change such as prolonged droughts and saltwater intrusion¹⁴. The Bangladesh Ministry of Environment and Forests (MOEF) describes the salinisation of groundwater stores and fluctuation of soil salinity as a “major concern”, and has stated that this problem is a leading cause of soil degradation. Approximately 12,000km² of arable land in coastal and offshore areas are adversely affected by salinity²⁸.

As the impacts of climate change take hold, the economic and ecological consequences of salinisation will become increasingly profound. Experts are particularly concerned about the impact of rising salinity on ecologically-sensitive ecosystems such as the Sal forest zone in the North and the Sundarbans in the South. Research suggests that it will affect important processes such as forest regeneration and succession. Preliminary estimates indicate that the resulting forest declines could lead to a 50 percent loss of wood from the Sundarbans³¹. This will have major economic consequences for more than 300,000 people who directly depend upon this area for food, fuel and income^{32/33}. Mangrove decline will further undermine Bangladesh’s resilience to climate change, as the root systems of the Sundarbans also play an important role in stabilising coastal soils and providing a buffer for the coastal area from the winds and storm surges associated with cyclones³⁴.

The Government of Bangladesh warns that a large part of the rural economy, particularly in the coastal areas, stands to be affected by climate change in the coming decade. Nationwide, climate variability may result in US\$26 billion in lost agricultural GDP between 2005 and 2050: equivalent to 3.1 percent of agricultural GDP per year³⁵. The United Nations Development Programme (UNDP) identifies climate change, global food price volatility and increased prices of fuel and fertilizers as some of the greatest obstacles to MDG targets on hunger and nutrition in Bangladesh¹⁴.

Climate change may reduce rice yields significantly © EJF



Threats to a dietary mainstay

Rice is the most important crop grown in Bangladesh; it is a dietary mainstay cultivated by almost 13 million families^{36/37}. Therefore, the impact of climate change on rice yields is a serious concern. An increase in the atmospheric concentration of CO₂ along with a temperature rise could, in theory, increase rice productivity, particularly for the *Boro* (dry season variety) rice crop. However, it is also possible that reduced freshwater availability combined with other stresses will offset the positive impacts of climate change. A 60 percent moisture stress in rice plants (due to decreased water availability) could result in as high as a 32 percent decline in *Boro* yields²⁴.

Other varieties of rice may fare even worse. Research indicates that a temperature rise of 1-2°C could cause rice plant sterility, and that a rise of 4°C could decrease rice production by as much as 28 percent²⁸. Of the three rice crops grown in Bangladesh, the *Aus* rice crop (grown during the summer monsoon) is considered to be the most vulnerable²⁴. Rice yields are predicted to decline by as much as 80 million tonnes over the next 50 years – a decline equivalent to almost two years worth of rice production³⁸.

The UNDP has identified climate change as one of the greatest obstacles to MDG targets on hunger and nutrition

Community-based adaptation to climate change

There are examples of good practice at a community level which are helping to relieve the impacts of high intensity flooding on livelihoods and food insecurity. Farmers in Jamalpur, a northern district in the Dhaka division, have begun share-cultivating fish and rice (a method called integrated agriculture-aquaculture) in floodplains and during the flood season. Others have found they are able to avoid crop losses by transplanting early or late-maturity varieties of *Aman* rice (the rainy season variety usually harvested in November-December). Successes have also been observed in communities using hydroponics, where vegetables are grown in floating gardens and thus have greater protection from flooding. Where declining water availability is the predominant factor restricting growth, such as in the drought-prone Barind Tract, some farmers have shifted to the cultivation of plants that are naturally more resilient or less water intensive, like mangoes and jujube²⁵.



A floating garden in Bangladesh © Practical Action / www.practicalaction.org



“We have a continuous lack of food. Now I am not old, and I can go and work, so somehow I am able to sustain my family. But people in their seventies, eighties and nineties, many of them cannot work. Many of them go a whole day without eating.”

- Name:** Anil Krishna Roy
- Age:** 45
- Occupation:** Former fish farm worker, now working in the informal sector
- Home:** Jaliakhali village, Dacope, South West of Chalna

Anil Krishna Roy lives with his wife and children in the riverside village of Jaliakhali, about 20km south of Khulna city in South West Bangladesh. He used to be employed as a worker on a fish farm in the village, but now that his village floods with every high tide no fish or crops can be cultivated.

In 2009, one of the most devastating storms in recent decades, Cyclone Aila, passed west of Jaliakhali. Strong winds and a storm surge created a large break in the embankment and severe damage to the dam protecting the village. The ensuing deluge of river water covered almost the entire village area, destroying the schools, temples and the bazaar. Families were only able to save what possessions they could physically carry in a single load and thus few were able to save livestock and food.

The first relief efforts after the storm focused on securing a food supply. Emergency rations of puffed rice, jaggery (unrefined sugar) and other dry food were distributed, followed later by small cash donations. However, recovery in the area has been slow. The breach in the embankment has not been repaired, so the area continues to flood with every high tide.

All low-lying land is now covered by a thick layer of alluvial clay, whilst the soil has been rendered infertile due to the saline conditions associated with the daily intrusions of brackish water. Neither farming nor fisheries are now possible and there are few other jobs available. Eighteen months after Cyclone Aila struck, a number of families remained reliant on the monthly ration of 18kg of rice and limited financial assistance provided by local authorities.

Support of this nature is a lifeline but is not sustainable. This assistance is only enough to support families for a small proportion of each month, with the elderly being worst affected. People have been pushed into desperate situations: *“In some families there is no one to work, only many women. There may be an old father who is unable to work. They have no alternative but to beg.”* Anil is unemployed and relies on scavenging wood and fishing in the river to derive a small income and feed his family. Four other families have already left the area and Anil believes that eventually he will have to leave and look for work outside of the village.

“Everything in our country is changing. The work we used to do in each season, now we are unable to do the same work in same season...in the last four or five years we are unable to do anything. We are trying but nothing is happening. Now our livelihood is in danger.”

- Name:** Dilipur Kumar Mandor
- Age:** 70
- Occupation:** Farmer
- Home:** Golardangi village, Ramphal thana, South East of Chalna

Dilipur Kumar Mandor cultivates brinjals, tomatoes, radishes, rice and betelnut and coconut trees. Although he is only a small-scale producer, Dilipur used to be able to grow enough to feed his family with produce left over to sell. However, now crops are failing.

In 2010, Dilipur sowed 40kg of rice seed but no rice grew. He attributes this to environmental changes. Like the millions of other farmers in Bangladesh, Dilipur works according to a traditional farming calendar made up of six seasons. Increasingly unpredictable weather means that long-established farming methods are failing farmers. He reports that *“now we see warm weather during winter and cold weather during summer”*. A lack of rain is making it harder than ever to produce adequate yields.

Increasing salinity is also a significant problem: Dilipur, his family, and more than a thousand other people living in the area rely on a single open water pond to meet all their freshwater needs, including the water needed to raise livestock. There used to be more freshwater sources, but others have been polluted or contaminated with salt.

The quantity of fish and vegetables that Dilipur’s family eat has declined dramatically. They very rarely consume meat as there is not enough water and food to maintain the community’s cows, goats, ducks and hens. Instead of growing rice the family now has to buy it, priced at around 30-32 Taka (about 40 US cents) per kilogram.

Overall household incomes in the region appear to have declined, and the inability to farm their own food is putting families in a worse financial situation. Even those incomes perceived to be more secure than farming, such as small businesses and shopkeeping, are being affected. Poverty and food insecurity are so severe in Ramphal thana that Dilipur believes that within two or three years people will no longer be able to live there.



A nation at risk

The World Health Organization (WHO) has stated that climate change affects fundamental requirements for health such as water, food, shelter and a safe environment³⁹. Some of the world’s leading causes of death are climate-sensitive. Climate change has a direct impact on lives and health through exacerbated hazards such as heat waves, floods and storms. It also has a more complex, indirect impact through altered infectious disease patterns, disruptions to agricultural and other supportive ecosystems, and potentially through displacement and conflict over depleted water, food and land resources⁴⁰. The United Nations Office of the High Commissioner for Human Rights (OHCHR) projects that the traumatic, infectious, nutritional and psychological health impacts of climate change will be most profound in Sub-Saharan Africa, the Middle East and South Asia. Pre-existing poor health in these regions increases their vulnerability to climate change and reduces the capacity of their populations to adapt⁴¹.

Living in harm’s way

The first and foremost concern in regards to the impacts of climate change on human health is loss of life. This stands as one of Bangladesh’s greatest challenges, having a large population living in harm’s way. Bangladesh is the ninth most populous country in the world, and its population competes for space in an area not much bigger than the State of New York. The combination of this high population density and poverty has resulted in a high incidence of landlessness. Approximately 4.5 million households in the country are landless or functionally landless (owning less than 0.2 hectares of land)⁴². As a result, many people are forced to live on hazard-prone, marginal land that often lacks the infrastructure and facilities to withstand the impacts of climate change⁴³.

More than five million people live in coastal areas at ‘High Risk’ from cyclones and storm surges, and about four million of these are located in ‘Very High Risk Areas’²⁸. It is through these kinds of extreme events that sea level rise has been and will continue to be felt most acutely⁴⁴. Storm surges are often the most lethal part of a cyclone, with a rapid onset and travelling up to 30 miles inland^{31/45}. Many of the world’s most damaging storm surges have hit Bangladesh: of the 34 reported with loss of life of 5,000 or more, 26 have occurred in the Bay of Bengal⁴⁶. The highest storm surge in the region from the past century, associated with the 1970 Bhola Cyclone, reached an estimated height of 10.6 metres and killed as many as 300,000 people in Bangladesh^{46/47}. Peak intensity of tropical cyclones in the region is projected to increase by 5-10 percent and the cumulative effect alongside the rise in sea level could increase the dangers posed by storm surges in Bangladesh considerably³¹.

An insidious threat

The impacts of climate change on health are not always inflicted during headline-grabbing events like storms and floods and slow onset, climate-related disasters can be equally devastating. With its land surface covered by a network of more than 700 rivers, tributaries and water courses, Bangladesh is rich in water resources. Yet, large areas can experience water scarcity and drought.

The country is affected by major country-wide droughts on an average cycle of around five years but localized droughts are more frequent. The North West region (and particularly the upland areas of it known as the Barind Tract) experiences the most severe droughts on average, the worst of which can damage as much as 40 percent of the rice crop planted to coincide with the late dry and early monsoon season. In the *Rabi* season (typically November to February) more than 10,000km² of arable land can be affected by drought. It damages crops that are vital for local and national food security, pushes up rice prices, and reduces the income of, and therefore potential for farmers to invest in the agricultural sector⁴⁸.

Drought also results in an increase in the prevalence and duration of seasonal food crises (called *monga*) and nutrition-related illnesses⁴⁸. Meanwhile, the reduction in freshwater availability during drought events compromises the ability of households and communities to attain or maintain sanitary and hygienic conditions.

Worldwide, diarrhoeal diseases are the fifth leading cause of death, killing more than 2.2 million people each year⁴⁹. In a low income country, like Bangladesh, the relative threat is considerably higher: diarrhoea is responsible for one in eight deaths of children under-five⁵⁰. Experts believe the incidence of diarrhoea could increase in Bangladesh due to the combined effect of changes to temperature, rainfall, the nature of pathogens and viruses, and limitations on access to safe water and sanitation infrastructure^{51/39}.

The taste of salt

Around 20 percent of the Bangladeshi population (33 million people) rely on water sources like rivers and open ponds to meet their daily water needs⁵². The susceptibility of these water sources to contamination by substances like arsenic and salt leaves those reliant on them vulnerable to health problems. A health survey of residents in the Satkhira district revealed a link between increased salinity and hypertension, premature delivery due to pre-eclampsia, acute respiratory infection and skin diseases⁵³. Similar findings were revealed by research in the south western area of Dacope, where a large proportion of the population was found to consume 5-16 grams of sodium (a major component in salt) per day from drinking water alone, which greatly exceeds the WHO daily recommended limit of two grams. Expectant mothers were found to have significantly higher rates of hypertension and pre-eclampsia compared with non-coastal pregnant women during the dry season when water salinity peaks, suggesting that these health problems are linked to contaminated drinking water⁵⁴.



33 million people in Bangladesh rely on water sources like this open pond in Ramphal thana to meet their daily needs

© EJF



“They say, in Bangladesh, that climate change has a taste and it tastes of salt.”

Rabab Fatima, International Organization for Migration Bangladesh⁵⁵



Approximately 12,000km² of farmland are adversely affected by salinity

© EJF



Society’s most vulnerable

“The problem for women in the village is that when a cyclone comes most of us don’t really make for the cyclone shelters because we can’t swim properly. Some die just staying in their homes.”

Johora Begum, resident of Majher Char⁵⁶

Women, children, the elderly, ethnic minorities, marginalised communities and those with disabilities are most at risk of the negative impacts of climate change⁵⁷. The disproportionate threat these groups face is evident in the fatalities of past disasters. For example, 90 percent of fatalities caused by Cyclone Gorky in 1991 were women and children⁵⁸. This is due in part to underlying social inequalities, since these groups are more likely to encounter obstacles on access to resources, information and skills training and decision-making⁵⁹. It is believed that many women and children perished in the cyclone at home while waiting for the male head of the household to return and to make a decision on evacuating⁶⁰. Skills (such as the ability to swim), roles within the household and social norms that regulate clothing also contributed to the demographic spread of fatalities^{60/61}.

Vulnerability of these groups can also be linked to biological traits⁶². For example, menstruation, pregnancy, childbirth and breastfeeding are uniquely female functions that make women particularly vulnerable during and after natural hazards. During the 1998 floods in Bangladesh, WHO observed that many adolescent girls suffered from perineal rashes and urinary tract infections because they were not able to wash their sanitary rags properly in private, often having no place to hang the rags to dry and without access to clean water⁶⁰. Physical size, strength and endurance are also important factors which contribute to the relatively high proportion of deaths of women over 40 years old and children under 10 killed during the 1991 cyclone⁶⁴.

Rexona, resident of Sarankhola

© EJF



“My brother and my father were in a boat. When the cyclone came the boat was destroyed. My father was an old man, he couldn’t really swim. In the morning, my brother swam back and told us that he couldn’t find our father. My husband and my brother went looking for him and after three days they found his body, floating in a pond quite far from here.”

Rexona, resident of Sarankhola⁶⁵

No place like home

The housing sector typically experiences the most tangible impacts of natural hazards. Often the damage or destruction is more extensive than just the physical structure of a property. It can include the loss of household items including bedding, kitchen utensils and clothing, and spaces for food preparation, storage, washing and toilet facilities. In the absence of these things people may struggle in daily tasks such as cooking and cleaning, with a lack of privacy and the means to ensure their dignity.

Climate-related natural hazards such as storms and cyclones, flooding and river and coastal erosion all pose a threat to the housing sector in Bangladesh. The three major rivers (Brahmaputra-Jamuna, Ganges-Padma and Meghna) coursing through the country are responsible for some of the most dramatic scenes of river erosion in the world. These rivers have eroded a total of 1,800km² of land in the last 30 years⁶⁶. In 2010 alone, more than 16km² of land along the Brahmaputra-Jamuna, Ganges and Padma rivers were considered vulnerable to river erosion, putting around 4km of embankments, 7.5km of roads, 4km² of settlements, 23 educational institutions and four health centres at risk⁶⁷.

Erosion is most acute in the coastal estuaries and channels which face strong tidal flows and storm surges. Here rivers are filled with thousands of cubic metres of tidal water from the Bay of Bengal and water transported down from upstream areas⁶⁸. Coastal islands like Bhola, Sandwip, Hatya and Kutubdia have been particularly badly affected. Sixty-five percent of Kutubdia’s land area has been submerged in the last 100 years and more than 60 percent of the inhabitants have migrated⁶⁹. If coastal erosion rates remain constant here and no intervening action is taken, the islands of Kutubdia and Bhola could be submerged within 40 years⁷⁰. By 2050, peak river discharge could increase by up to 10 percent, which would cause an average increase of 20 percent in the erosion rate along the riverbanks of the Brahmaputra-Jamuna if the existing conditions prevail⁷¹.

Rising sea levels will also contribute to a net loss of land area across the low-lying coastal region. By 2050, with a projected 50cm rise in sea level, Bangladesh may lose approximately 11 percent of its land, affecting an estimated 15 million people living in the region⁷². A projected 1m rise would inundate 18 percent of Bangladesh’s total land area, and directly threaten the lives and livelihoods of one in 10 people in Bangladesh. The subsequent backwater and increased river flow could ultimately affect as much as 60 percent of the population³¹.



Only around two percent of Bangladesh’s rural poor can afford to build their homes from more resilient materials like concrete and brick⁷³ © EJF



Haowa Begum and her son in their new home in Khulna © EJF

“I am not sure how many families left the village, but a lot of them have done so. I may not return to the village. I have no place to live in. The house is not safe. There will be more floods in the future.”

Haowa Begum, resident of Tupera Taltola slum, Khulna⁷⁴

“We went home [after the cyclone had passed] and saw that there was nothing left. There wasn’t a single house that you could live in. Only the houses built around trees, somehow their structure was still there, but they were unlivable. All the mud houses, clay houses were completely gone.”

Ataur Rahman, former resident of Patuakhali⁷⁵



1.5 million houses were destroyed by Cyclone Sidr⁷⁶ © EC/ECHO/Oliver Brouant

The vast majority of riverbank villages and towns are protected from flooding and erosion by earth and clay embankments. The structures must withstand the turbulent water currents found within the country’s powerful river systems and the constant meandering of river channels. Rainfall and animal and human activities also all undermine the structure and strength of these embankments on a daily basis⁷⁷.

The specific challenges for Bangladesh’s river islands

Chars are river islands formed as a result of erosion and deposition of sediment. They typically suffer from high salinity, offer limited freshwater resources or sources of fuel and have poor infrastructure¹⁸. Located within some of the world’s most powerful river systems, they can be formed and eroded rapidly during times of peak river flow or flooding and can disappear completely within the space of days or weeks. Despite this risk, lack of land availability elsewhere means that a large number of chars are populated⁷⁹.

The incidence of poverty can be particularly high on chars. Around one third of households inhabiting chars in the Jamuna River (an estimated 300,000-400,000 people) live in ‘extreme poverty’, subsisting on little more than 70 US cents a day and owning less than US\$70 in assets⁸⁰. These are some of the poorest and most food insecure people in Bangladesh⁷⁹. It is estimated that char residents move between five and seven times in a generation because of river erosion or flooding^{79/81}. This pattern of movement has given rise to the concept of a ‘char lifestyle’⁸². Already vulnerable, repeated displacement of this kind has the potential to trap people in a cycle of poverty.



The raised area in this photograph (centre) was once the foundations of a house © EIJ



Majher Char is one of the islands that have emerged in Bangladesh’s rivers

© EIJ

“This village was destroyed in three days. 150 people used to live in this part of the village. We all had to flee in three days.”



Quaran Ali © EIJ

- Name:** Quaran Ali
- Occupation:** Ward Representative for Berabari village, Berabari Char
- Home:** Berabari village, Berabari Char

Quaran Ali’s family has lived on Berabari Char for generations. He was one of the people displaced 12 years ago when the char disappeared.

Berabari village is situated on one of the many chars that have emerged in the Jamuna River to the East of Sirajganj town. At its most developed, Berabari Char had two schools, a bazaar and was home to hundreds of people. The char has always been under threat of river erosion, but around 12 years ago the rate of erosion rapidly increased. In a matter of days, wave action undercutting the bank of the char had undermined the whole structure, and the char and everything on it was washed into the river.

Like their neighbours, Ali’s 22 family members salvaged what possessions they could and then took boats to Sirajganj. Most settled in a roadside slum close to the riverbank. The conditions in the slum were extremely cramped, and living in illegal settlements meant that residents lived in fear of forced evictions as part of slum clearance schemes.

Quaran Ali and his family lived in the slum area until new sediment was deposited and Berabari Char reformed. In order to encourage repopulation of the char, Quaran Ali and his elected counterparts secured funding to create a raised area of land to make homes and assets more safe. However, it is very difficult for residents to recover financially from their original losses. Most families on the char are extremely poor, and Quaran Ali is concerned that they will struggle to meet the costs of rebuilding their homes themselves.

Climate change and displacement

Rising temperatures, increasingly erratic rainfall and worsening storms and flooding linked to climate change have resulted in the loss of homes and assets, land degradation, severe declines in water and food security, increasing pressures on human health and the collapse of rural livelihoods. These pressures place additional burdens on communities that are for the most part living in poverty already.

Some households have the capacity to recover from the ‘shocks’ of sudden onset natural hazards, or the resilience to withstand deteriorating environmental conditions, which may enable them to remain *in situ*. However, where there is a direct and immediate threat to life, or where environmental pressures compound socio-economic stresses and households cannot adapt, whole families are being forced to move. Large numbers of people are finding themselves in a situation where they have nowhere to go and are deprived of a means to survive. They are, in effect, ‘climate refugees’.

In some cases, it is easy to identify the role that the environment has played in displacement, for example where households and communities have been evacuated in the wake of a cyclone or during floods. In other cases, however, particularly where living conditions are gradually worsening, those who move are more likely to be identified as ‘economic migrants’ even though they have fled conditions where they have been denied their human rights⁸³.

Bangladesh has always had a highly mobile population, but migration flows are changing and growing as a result of climate change

Internal displacement

Most people displaced wholly or in part as a result of declining environmental conditions are likely to relocate relatively short distances from the area they originate from. Research indicates that mass displacements from developing to developed countries are very unlikely⁸⁴⁻⁹¹. Cultural and social connections root people to places, and are likely to influence the distances across which people relocate and resettle. Furthermore, few of the affected households have the logistical or financial capacity to undergo an international relocation^{90/84}. This has always been the case in Bangladesh, where the poorest parts of the country, such as the *monga* - affected districts in Bangladesh’s North West, account for only a very small proportion of international migrants⁹².



More than 880 new migrants arrive in Dhaka each day © EIJ

Displacement to cities

There is evidence to suggest a link between environmental insecurity and rural-to-urban migration in Bangladesh⁹⁴⁻⁹⁶. Rural communities whose livelihoods are heavily reliant on ecosystems are most vulnerable to environmental change, thereby increasing the likelihood of being displaced. The perception of cities as hubs of employment opportunities encourages movement from rural areas to urban settlements.

Bangladesh’s capital, Dhaka, increased in population size by 966 percent between 1970 and 2010⁹⁷, and an average of 880 new migrants arrive from rural areas every day⁹⁸. Rapid and unplanned urban growth can contribute to overcrowding and increased pressures on infrastructure, services and resources. Rabab Fatima, Regional Representative for South Asia for the International Organization of Migration (IOM), warns that there are implications for human security; “*Water shortages are now a very serious problem in Dhaka. Power shortages are also a very serious problem. In the slum areas, there are also health challenges. Crime cannot be ruled out.*”⁹⁹

Future projections indicate that existing socio-economic vulnerabilities within cities stand to be amplified by the impacts of climate change. Poorer residents are likely to be worst affected because they typically live in more vulnerable locations and in poorer quality housing¹⁰⁰. In Bangladesh, the impact on cities will be acute. An estimated 90 percent of assets in large port cities worldwide which are exposed to the impacts of climate change are situated in just eight countries. Bangladesh is one of these countries. Dhaka and Chittagong are likely to be the two cities with the highest proportional increase in the number of people exposed to rising sea levels¹⁰¹.



Rapid and unplanned urban growth puts significant pressure on urban resources, leading to widespread declines in living conditions particularly for the poorest households © EIJ

“[Those facing difficult situations] don’t want to leave their native place. They don’t want to leave the lands of their forefathers, to leave their own place and come to a new place.”

Yusuf Sheikh, resident of Tuperia Taltola slum, Khulna⁹³



“People who are well educated and get jobs are bound to move, but we did not have any other option about moving. Gradually everyone is fleeing the place in search of security and livelihoods. They are now vacating the village daily.”

- Name:** Yusuf Sheikh
- Occupation:** Flour mill worker
- Home:** Tupera Taltola slum, Khulna

Yusuf Sheikh lives in Khulna city with his wife and son. He moved there from a village in the South having lost his home, possessions and job and being unable to find alternative employment.

Yusuf Sheikh used to live in a six-roomed house in a village of around 25,000 people located near Mongla, close to the Sundarbans. Yusuf estimates that his family had been living in the area for 20 generations. He worked as a labourer on one of the large shrimp farms. Working conditions in the farm were poor, but as a contracted labourer he and his family had the assurance of a monthly income. This income was essential as shrimp farming had contaminated the freshwater sources and soil with salt, making it hard for residents to grow staple foods like fruits, vegetables and rice locally.

Throughout his life, Yusuf has witnessed the village flooding during rainy season (June to early October). However, in the past six or seven years, the floods have become less predictable in their timing and more severe. Residents fear that the village could be inundated at any time, even at night when it is more difficult to react.

In 2010, unusually heavy rains in September and October caused river levels to rise rapidly. With little time to prepare or plan, residents quickly found their land and properties inundated as the flood defences were overtopped and canals throughout the village overflowed.

Yusuf’s house was destroyed. His ducks and hens were killed and all his family was able to salvage was four plates, four cooking pots, a jug, some clothing, four blankets and two pillows. Within a few days, they faced starvation and were forced to leave their home and their village. They decided to follow other families leaving the village for larger urban settlements like Sirajganj, Khulna and Dhaka.

Yusuf’s father-in-law arranged a job for him in the flour mill, where he currently works 15 hours a day, six days a week. With this income Yusuf and his family can only afford to rent a one-roomed house in a slum in Khulna city. Contact with their few relatives and friends who are still living in Mongla is infrequent. Yusuf would like to return home, however the threat posed by flooding is too grave.

“It was getting harder and harder to live in a boat with our kids and so I said to my husband - let’s go, I can’t take it anymore, I can’t do it anymore. Please let’s go to some other district. At least we will live.”

- Name:** Taslima Begum
- Occupation:** Domestic worker
- Home:** Jama’at Khana slum, Khulna

Taslima Begum and her husband own 10 kathas (approximately 0.7km²) of land in Patakhali village in South West Bangladesh but live in a small slum in Khulna after their house was destroyed by flooding.

Heavy rainfall caused by Cyclone Aila caused the river next to Patakhali to burst its banks, submerging the village in waist-deep water within minutes. Taslima was still in her home as the floodwaters began to tear it apart. Like many other women in her village, she was unable to swim so relied on her husband to ferry her and their children in his fishing boat from the house to a sheltered, raised area. At that time there was no purpose-built cyclone shelter in the village. Taslima watched as the site of their house was submerged by a wall of water 6m high. The entire structure of the house and its foundations were washed away.

Even after the storm had passed the area remained flooded. Taslima and her family were unable to salvage any possessions or building materials from their house. They had no choice except to remain on the fishing boat, where they lived for two months. The family received some puffed rice and water rations as part of emergency relief efforts in the area, but most assistance came from their neighbours who lent them clothes, cooking utensils and food.

Living on the boat required the family to wash themselves, their clothes and cooking utensils in the river, relying on their neighbours again for access to a latrine. In addition to a lack of protection from the weather, this living arrangement gave the family no privacy. Poor nutrition and waterlogged conditions eventually began to impact on their health and Taslima suffered from severe pain and swelling in her limbs.

Taslima’s family decided to leave the village. Having no land anywhere else in the country, and therefore no other resettlement options, they travelled to Khulna on the expectation that there would be more employment opportunities there than in another rural village. Taslima and her family lived on the street for two days before they were able to move into a house available for rent in one of Khulna’s smaller slums. The house is one of a circle of single-roomed, wooden houses constructed around an open pond filled by drain water. The stagnant water provides a breeding ground for mosquitoes, which are now a major problem for residents.

Whilst both are now employed, Taslima and her husband still have a relatively small household income. It is not enough to allow them to buy more land and their children must go to work rather than school in order to provide further financial support.



A legal void

“A growing number of people are uprooted by natural disasters or lose their livelihoods to desertification, with climate change now found to be the key factor accelerating all other drivers of forced displacement. These persons are not truly migrants, in the sense that they did not move voluntarily. As forcibly displaced not covered by the refugee protection regime, they find themselves in a legal void.”

António Guterres, United Nations
High Commissioner for Refugees¹⁰²

The first response to climate change must be preventative. There is an urgent need for national governments to be far more ambitious and committed to cutting GHG emissions. Developed countries must commit to a 40 percent reduction in GHG emissions below 1990 levels by 2020, achieved through, amongst other things, increased renewable energy production. Greater funding must be made available for mitigation and adaptation. Increasing the adaptive capacity and resilience of communities affected by climate change to enable people to stay *in situ* must also be a focus of any strategic approach in responding to climate change. At present, spending on both is around 11 percent of what is estimated to be needed⁷².

A coordinated response to climate change-induced displacement

Climate refugees face an uncertain future, unrecognized and largely unaided by the international community. Globally, people displaced by climate-related, natural hazards now outnumber refugees fleeing persecution and violence by more than three to one^{105/106}. However, unlike refugees, those displaced by environmental factors have no legal status. There is no legislation, agency or institution specifically mandated for the protection and assistance of climate refugees.

A more comprehensive and coordinated international response is required where displacement has occurred as a result of deteriorating environmental conditions associated with climate change. No existing frameworks or institutions in the domain of migration, displacement or climate change precisely and definitively address the issue of climate refugees, and no international agency has a clear mandate to serve displaced people who need human rights protection and humanitarian assistance.

For these reasons, a new, legally-binding instrument is urgently needed. This could provide a recognized, legal status for people displaced as a result of deteriorating environmental conditions. This would also secure the obligation on national governments to establish specific policies for their assistance and protection⁸⁶. Effective multilateral cooperation, underpinned by the principle of common but differentiated responsibility, could help to prevent the worst-case scenarios of climate change-induced displacement being realised, and potentially ameliorate some of the adverse consequences of rapid and unplanned rural-to-urban migration seen in many countries.

Where relocation is necessary, it must be planned and voluntary. The governments of affected communities and regions need to be supported in order to provide adequate compensation for lost income and assets, and assistance for relocation, recovery and resilience-building for those affected. Where return or repatriation is not viable, relocation must take the form of planned and voluntary resettlement and reintegration. In these cases, decision-making must be transparent and consultative. The international community should assess existing relocation projects to determine models of good practice.

Governments and the international community should also recognize the role of ‘positive’ migration as a strategy to diversify income, enable adaptation *in situ* and prevent displacement. Planned and managed migration can be beneficial to both donor and recipient areas. There are successful examples of labour migration schemes that could be assessed as models of good practice, including New Zealand’s quotas for people from Tuvalu under the Pacific Access Category (PAC) and the flow of migrants between Colombia and Spain as Temporary and Circular Labour Migration (TCLM).

In the first 10 months after Cyclone Aila only 10 percent of households in affected areas recieved any kind of government or NGO support¹⁰³



Living on the brink. A home sits on a heavily eroded embankment © EJF

“I have seen people struggling, but I never thought that that would be me, that it would be my nieces and nephews and my neighbours who would be suffering like this. I have never seen anyone struggling or suffering that much.”

Ataur Rahman, describing the devastation caused by Cyclone Aila in his home village¹⁰⁴

MOVING FORWARD: ensuring protection and assistance for climate refugees

There are a number of fundamental concepts that must provide the foundations of a global guiding framework for the recognition, protection and assistance of climate refugees¹⁰⁷.

1. The negative impacts of climate change will result in irrecoverable damage to land, homes and livelihoods. Resettlement and reintegration will be necessary for those people who have been displaced and for whom return is not a viable option as a result of the negative impacts of climate change. Those permanently displaced must receive equivalent entitlements as citizens in recipient destinations.

2. People are likely to be displaced by climate change on a large scale and collectively. A coordinated response to displacement must be scalable to a household, community and national level, as will be necessary for a number of small island states facing rising sea levels and exacerbated erosion.

3. The impact of climate change on migration and displacement will increase over time. The international community must develop a strategic approach to the projected impacts, as opposed to implementing ad hoc emergency relief responses.

4. States share a common but differentiated responsibility for climate change. Whilst responses to the human impacts of climate change are likely to be predominantly coordinated at a national level, these efforts must be supported by the international community. The planned resettlement of millions of people will require substantial funds, which should be committed under a global fund, and should include innovative and equitable funding streams.

Conclusion

Bangladesh is one of the poorest countries in the world and its GHG emissions represent a tiny proportion of global emissions. However, it is already severely affected by environmental insecurity linked to climate change, and is paying the ultimate price in terms of its progress on development and the effective enjoyment of human rights.

Evidence presented in this report shows that it is becoming increasingly difficult for a large proportion of people in Bangladesh to meet their basic daily needs. Food and water insecurity is increasing, livelihoods are collapsing, and lives are under threat. Where adaptation is impossible, whether through lack of capacity or because conditions are untenable, some are being forced to abandon their homes and land. These people are climate refugees.

It is evident from this country study that climate change is not a problem solely for the future, but one that faces us now. Short-sighted political agendas and inaction will ultimately amplify the human and financial costs of climate change. There are a number of areas where international and national responses to this humanitarian crisis must be refined and upscaled, as outlined in this report. Far greater emphasis must be placed on protecting human rights that are under threat as a result of deteriorating environmental conditions associated with climate change. There is also an urgent need for a new, legally-binding instrument for the recognition, protection and assistance of those people who have been forcibly displaced from their homes and who are now climate refugees.



Children make a bridge across a flooded slum in Khulna © EIJF

Recommendations

1. An international, binding agreement on legal recognition, protection and assistance for climate refugees.

- National governments should support the development and implementation of an international, legally-binding instrument that confers recognition, protection and assistance to climate refugees.
- National governments should also collaborate to develop and implement an innovative funding mechanism for this instrument, based on the principle of common but differentiated responsibility, supporting the needs of countries that are most vulnerable to climate change and least able to adapt to its effects.
- Individuals should press their government to show leadership on climate change and displacement, and to support a new legal agreement.

2. Greater commitment and accountability on climate change mitigation.

Worst-case scenarios of climate change can still be prevented through robust, ambitious GHG emissions cuts.

- Developed countries should make legally-binding commitments on GHG emissions reductions targets, including a 40 percent reduction in emissions from 1990 levels by 2020.
- Developing countries should make binding commitments to improve efficiency across their economic sectors and reduce their total GHG emissions.
- Individuals should reduce their own carbon footprints through careful consumption, reducing wastage, recycling and investment to increase their domestic energy efficiency.

3. Greater support for adaptation and assistance in ‘frontline’ countries.

Even with immediate targets agreed and implemented, historical GHG emissions will have long-term effects. Efforts must be made to abate the negative impacts of climate change, with particular support for developing countries that are least culpable but already experiencing some of the worst effects.

- Countries should collaborate to ensure increased and more equitable, transparent and timely distribution of funding for climate change adaptation.
- Greater financial support should be given to reducing vulnerability to climate change, disaster risk reduction and sustainable development to enable adaptation *in situ*. The overall goal must be to help prevent humanitarian crises, rather than to react to them.
- Developed countries should facilitate green technology transfer to developing countries and support locally appropriate technologies to reduce GHG emissions and build environmental security.

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