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Fighting climate change:
Human solidarity in a divided world

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Impacts of Climate Change on Human Development

Liliana Carvajal

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Impacts of Climate Change on Human Development.

Scientific research throughout the past decades has demonstrated how climatic changes have important impacts on the livelihoods of people around the world. For most of developing countries their level of structural and social vulnerability, are a dangerous combination and a formula for impacts of higher magnitude. Therefore, climatic phenomenon such as tropical storms, floods and droughts, more often become tragedies in these countries. This paper analyzes the impacts of such phenomenon in the human development of people across the world. Some of the climate change related issues analyzed in this paper are: droughts and water security, tropical cyclones and storms, rising tides, warming seas, coral bleaching, fish stocks, melting glaciers, heat waves and cold spells and the impact on human health. These shocks are discussed in this paper along with the differentiated impact on countries in various levels of human development.

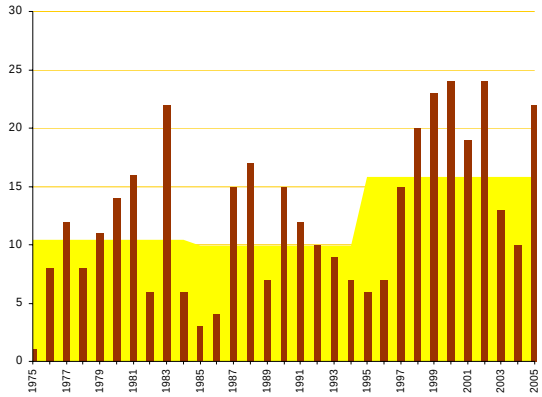
1. DROUGHT AND WATER SECURITY

Drought problems are projected for regions that depend heavily on glacial meltwater for their main dry season water supply (Barnett et al., 2005). Given that Approximately one-sixth of the Earth's population rely on glaciers and seasonal snow packs for their water supply and live within a low-reservoir storage domain, the consequences of projected changes for future water availability, predicted with high confidence and already diagnosed in some regions, will be adverse and severe (IPCC AR4, 2007). In the Andes, glacial meltwater supports river flow and water supply for tens of millions of people during the long dry season. Many small glaciers e.g. in Bolivia, Ecuador and Peru (Coudrain et al., 2005) will disappear within a few decades, adversely affecting people and ecosystems with rare and endemic species. Drought ranks as the natural hazard with the greatest negative impact on human livelihood (Barlow et al, 2006). On the other hand, within the existing and increasing context of growing population and climate change, demands for water will not be met, much less the demands of a growing economy. It appears that some areas of the most populated regions on Earth such as Asia are likely to 'run out of water' during the dry season if the current warming and glacial melting trends continue for several more decades (Barnett et al 2005).

1.1 Droughts - an increasing trend

Worldwide the annual average number of reported droughts has increased more than three-fold since the 1970s. During that decade there were 57 droughts, which correspond to an average number of six droughts per year, of which 33 percent were in Africa, 37 percent in Asia and 2 percent in Europe. In the 1990s the percentage of droughts in Africa jumped to 40 percent with a total 49 droughts reported in different parts of the region, mainly in East Africa. The 2000-2006 period saw an increase to 119 droughts, 46 of those in Africa, 34 in Asia and 12 in Europe (EM-DAT, 2007).

Figure 1 Number of Droughts worldwide 1975-2005 (shaded area is a 10-year average)



Source: EM-DAT: The OFDA/CRED International Disaster Database,
Université catholique de Louvain, Brussels, Belgium. April 2007.

1.1.1 Sub-Saharan Africa a drought-prone region

The population of the region was 690 million in 2004 with 455 million rural of which more than 90 percent % are agricultural. Rain fall is the most critical factor in determining the livelihoods of subsistence farmers and pastoralists with more than 90% of the region's agriculture being rain-fed. During the period 2000-2002, there were more than 850 million chronically undernourished people worldwide and sub-Saharan Africa accounted for 25% of this figure (FAO 2004).

In recent years, the largest food crises in Africa that required large-scale external food aid have been attributed fully or partially to extreme weather events (Dilley et al, 2005). The food crises of 1974, 1984/5, 1992 and 2002 that affected the lives and livelihoods of millions of rural households have been mainly caused by droughts (Haile, 2005)

Most of the population in the countries identified as experiencing high-drought frequency are agro pastoralists whose livelihoods are constantly threatened by rainfall variability. During the 1970-2004 period 14 countries reported droughts more than 10 times. Some of these drought prone countries are Somalia, Ethiopia, Eritrea, Chad, Sudan, Mali, Kenya and Senegal (CRED EM-DAT, 2007) (see map). These countries are among the poorest in Africa and are extremely vulnerable to drought risks (Dilley et al 2005).

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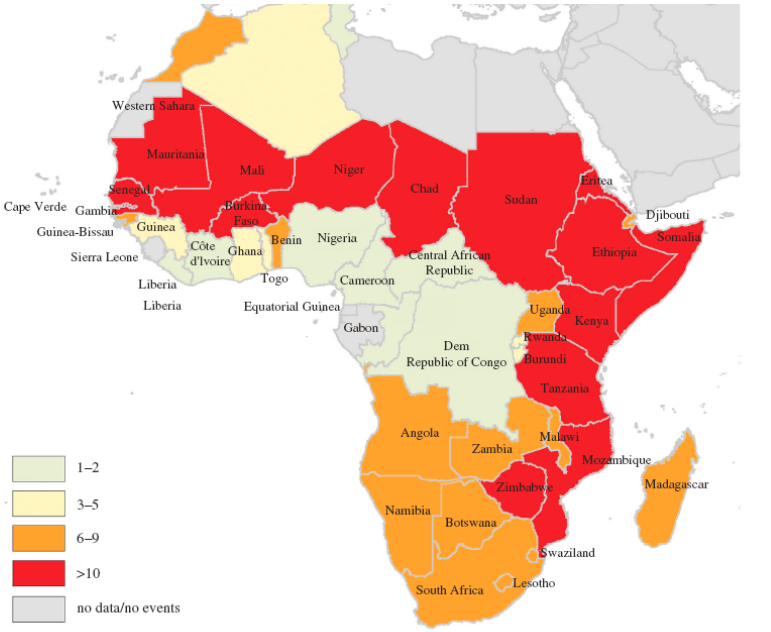
Figure 2 Sub-Saharan Africa - drought reports per country 1970-2004



data source: EM-DAT: the OFDA/CREDA International disaster database, Université catholique de louvain, Brussels, Belgium.

Source: M. Haile 2005.

In sub-Saharan Africa climate variability and extreme weather events such as droughts, excessive rains and floods are among the main risks affecting agricultural productivity and hence rural household food security (Haile, 2005)

According to the most recent climate change forecasting, increased precipitation intensity and variability is projected to increase the risk of floods and droughts in many areas. Considering the current conditions of food insecurity in sub-Saharan Africa, these projections are a life threat to the nearly 700 million people of the region.

A look at drought coping strategies explains the extent to which extreme events like droughts undermine all developmental gains and can trap the whole region in extreme poverty. Droughts not only threaten lives but also have a devastating impact on the livelihoods of the affected households. To cope with acute food shortages driven by droughts, households may be compelled to engage in economic activities and strategies that focus on meeting the immediate food requirements of their families. Common strategies are divesting of productive assets such as livestock and exchange their land for food; fire wood sale increasing deforestation, consumption of their seeds, pulling children out of school, job seeking migration in less productive sectors. In extreme cases complete households may abandon their villages and mass migrate to urban centers and refugee camps (Haile, 2005).

1.2 Water Security

As it is well known, water availability is central for all aspects of life from human health and economic activity to ecosystem function and geophysical processes. But the warming of the climate is affecting the hydrological cycle and therefore water availability. Climate models have estimated a 10-30% decreases in run-off in southern Africa, southern Europe, the Middle-East and mid-latitude western North America by the year 2050. Also 10-40% increases in runoff in eastern Equatorial Africa, La Plata basin and high-latitude North America and Eurasia. Such changes in sustainable water availability would have considerable regional scale consequences for economies as well as ecosystems (Milly et al 2005).

Over half of the world's potable water supply is extracted from rivers. The discharge of these rivers is sensitive to long-term changes in both precipitation and temperature, particularly in the snowmelt dominated parts of the world. Changes in the amount of precipitation affect the runoff volume and the levels of snow accumulation. Temperature changes also affect the timing of runoff. Increasing temperatures lead to earlier runoff in the spring or winter, and reduced flows in summer and autumn, in the absence of changes in precipitation. In a warmer climate, snow will melt earlier in the year than it did before and in some places this has already happened (Barnett et al 2005). Without adequate water storage capacity, these changes will lead to regional water shortages.

Semi-arid and arid areas such as Mediterranean basin, western USA, southern Africa and north-eastern Brazil are particularly exposed to the impacts of climate change on freshwater. These areas may suffer a decrease of water resources due to climate change.
Efforts to offset declining surface water availability due to increasing precipitation variability will be hampered by the fact that groundwater recharge will decrease considerably in some already water-stressed regions where vulnerability is often exacerbated by the rapid increase of population and water demand (IPCC AR4, 2007).

Box 1

The Himalaya-Hindu Kush – water supply at risk

The Himalaya-Hindu Kush (HKH) region conformed by China and parts of Asia, including India is perhaps the most critical region in which vanishing glaciers will negatively affect water supply in the next few decades. An important factor is the region's huge population (about 50–60% of the world's population). Today some of the Himalaya's glaciers, the largest mass of ice outside of the polar caps, are receding at a rate of 10–15 meters a year (WWF 2007).
The ice mass over this mountainous region is the third-largest on earth, after the Arctic/Greenland and Antarctic regions. Melting glaciers provide a key source of water for the region in the summer months: as much as 70% of the summer flow in the Ganges and 50–60% of the flow in other major rivers (Singh et al 2004). In China, 23% of the population (> 200 million people) live in the western regions, where glacial melt provides the principal dry season water source (Barnett et al 2005). Regions like this one that depends so heavily on glacial meltwater for their main dry season water supply will be facing serious water availability problems. The reason is that once the glaciers have melted in a warmer world, there will be no replacement for the water they now provide as opposed to the present snow-pack-dependent water supply that is renewed seasonally (Barnett et al 2005).

The China Glacier Inventory, recently released showed substantial melting of virtually all glaciers. A concerning issue is that the major source glacier for the Yangtze river, the most important river in China registered one of the most marked retreats in the last
13 years (750 m) (Meier et al 2002). The Yangtze Delta is one of the economically developed regions in China. However, given its location, the delta is climatologically sensitive. It is prone to flooding and sea level changes (Zhang et al 2005). It has been estimated that the entire HKH ice mass has decreased in the last two decades and its melting rate seems to be accelerating (Meier et al 2002).

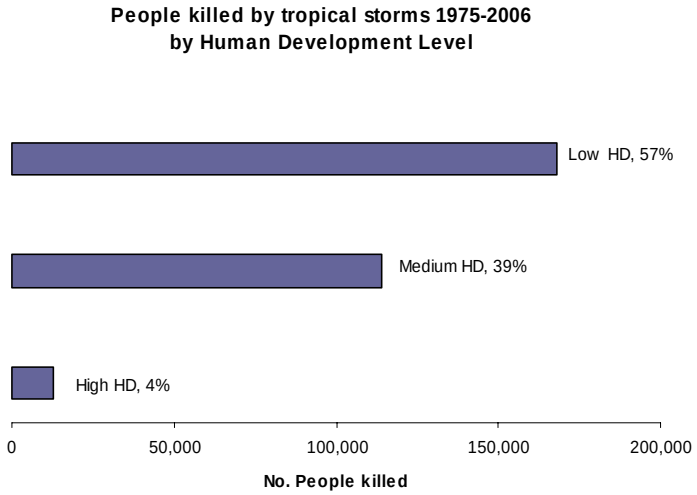
2 TROPICAL CYCLONES AND STORMS

Coasts are highly vulnerable to extreme events, such as storms which impose substantial costs on coastal societies. Tropical cyclones have major economic, social and environmental consequences for coastal areas. The most exposed countries have densely populated coastal areas, often comprising deltas and megadeltas (China, India, the Philippines, Japan, and Bangladesh) (UNDP 2004). Annually, about 120 million people are exposed to tropical cyclone hazards which had killed more than 270,000 people from1980 to 2006 (CRED, 2007).

The number of people killed by disasters is just the tip of the iceberg. Beyond that, there is a range of consequences that undermine all prospects for long-term progress.

2.1 Vulnerability and HDI

Even though risk is spread equally, vulnerability is highly skewed. Developing countries, and more specifically poor countries, bear the main human burden of climate related extreme events. From the total number of people killed from storms in the 1975-2006 period 57% were from countries in the low human development category and only 4% of the victims were from countries in the high human development range.



Data source: CRED EM-DAT, HDR2006

In terms of relative mortality due to extreme weather events, Honduras and Bangladesh are the countries with the highest vulnerability when measured in terms of the number of people killed per million population: 2,800 in Honduras and 1,400 in Bangladesh. On the other hand high income countries such as the United States[1] and Japan which had faced higher number of hazards with similar intensity face a lower vulnerability: 11 and 25 people killed per million population respectively.

2.2 Country and regional cases: recent heavy impact shocks

The late 20th century and early 21st century have seen really catastrophic weather related events, mostly in the Caribbean; hurricanes and heavy rains have struck with impunity leaving the most vulnerable areas in despair. Below are some briefs of particular catastrophic events in some of the most vulnerable areas due to exposure to weather related event (Central America, Mozambique, Haiti and Dominican Republic)

2.2.1 Hurricane Mitch 1998 (Central America)

Hurricane Mitch hit Central America on October 26-27, 1998. It killed nearly 19,000 people in the region. Hurricane Mitch was ranked the fourth strongest storm in Atlantic Basin history (Morris et al 2002). Mitch left a human toll of 3,332 people killed in Nicaragua and nearly a million badly affected and its marginalized economy was destroyed within 4 days. The reported damages were about the same as the country's 1998 GDP.
Honduras was the most affected country with 14,600 people killed and over 2 million affected. Also a significant number of crops were devastated, including the staples maize and beans; 58% of the maize crops and 6% of the beans crops were destroyed by Mitch. Official estimates place the number of houses

[1] The figures for the United States used for this analysis include the reported 1,322 victims of Hurricane Katrina in 2005.

completely destroyed by the hurricane at 35,000 with another 50,000 seriously damaged (ECLAC, 1999). This damaged affected some 662,000 people or just over one tenth of the country's population (Morris et al 2002). Poverty estimates based on the March 1998 and 1999 Encuesta Permanente de Hogares de Propositos Multiples (EPHPM) –a national household survey— suggests an increase in the share of rural households living in poverty following Mitch of about 5%, from 69.2% to 74.6% (Government of Honduras, 2001) however, these results are likely to be underestimated.
The outcomes in Honduras were very unequal between the rich and the poor. Even though the magnitude (value) of loss among those affected was over fifteen times greater among the wealthiest households compared to the poorest, the impact of Hurricane losses was much more significant for the poor: the people in lowest quintile of wealth lost nearly 6 times more of their asset value as compared to households in the highest quintile of wealth (Morris et al 2002). An important factor of high vulnerability for the poor is that their asset portfolio is not only very limited but also very risky.

2.2.2 Floods in Mozambique 2000

Mozambique is crossed – blessed or cursed- by many rivers, so when it rains heavily great part of the country gets flooded. Every year, at least two or three powerful storms are likely to hit the country. Every year the country faces extreme emergencies due natural hazards. At the moment the country is an emergency state due to the floods that had stricken it. Some 60,000 people are currently housed in emergency shelters or resettlement areas, while 4,600 homes, 11 school rooms and four health centres have been partially or totally destroyed. The Government of Mozambique has declared the region on full alert, in what may be the worst floods since 2001 when over 100 people perished.
As of February 2007, some 36,000 people had been displaced and some 43 schools were destroyed in Nampula and Sofala provinces (Relief web, April, 2007). Out of the whole southern Africa region that had been badly stricken by floods in the past months, Mozambique is the country with the highest number of displaced population (see map) Localised flooding is common during the southern Africa rainy season, but this year floods occurred earlier that usual and have been more wide-spread (OCHA Situation Report 2).

In February 2000 Mozambique experienced a major natural disaster caused by the worst flooding in 50 years as high rains in both Mozambique and South Africa caused the major rivers of the south to overflow. The rains that flooded the country took three months to stop. The floods were shortly followed by a tropical storm, Cyclone Eline. An estimated 800,000 people were displaced in the southern and central provinces of Maputo, Gaza, Inhambane and Sofala and nearly 4.5 million were affected. The floods and cyclone, in which homes, factories and critical infrastructure such as roads and bridges were damaged or destroyed, have been a major setback for the country.

2.2.3 Floods in the Dominican Republic and Haiti May 2004

The year 2004 was a particularly catastrophic year for Haiti in terms of storms. In May, seventeen hours of torrential rains caused flash floods and massive land and mudslides in the border between Haiti and the Dominican Republic. The Dominican town of Jimani and the Haitian town of Font Verettes were the most affected. More than 40,000 people were affected and 3,400 lives were lost: 80% of the victims were on the Haitian side and almost 2,000 houses were destroyed. Lack of preparedness and awareness of the risks involved on living close to river basins is one of many causes that increased vulnerability.

"… when the river rose and destroyed our town many of us that survived crossed the border to find support in Dominican Republic. In Haiti there is only hunger and no hope for overcoming this tragedy. We think that the demon triggered this tragedy and we are afraid that it will happen again" Maximiliane. Haitian living in Jimani, border town between the Dominican Republic and Haiti.

Adaptation as well as disaster reduction strategies in Haiti are practically inexistent. The depletion of natural resources and destruction of livelihoods continues in an unstoppable trend. Haiti faces a severe deforestation problem. According to FAO, in 1923 forests covered nearly 60 percent of the country. Today forests only cover around 3 percent. Massive deforestation increases the likelihood of floods and landslides to become catastrophic by annihilating the natural absorptive capacity of the land and causing the silting up of rivers that end up in massive floods.

Lacking alternatives, an adaptation and survival strategy for Haitians is to migrate illegally to the Dominican side of the island were resources are not as depleted and job opportunities –even in extremely low paid jobs such is sugar cane fields- are far better. Currently, the Haitian population in the Dominican Republic is approximately one million.

In Haiti, after decades of political instability, with more than 30 coup d'états in history, poverty reduction has never been the subject of a systematic policy or of a coherent program with precisely defined measures and objectives (I-PRSP 2006).

Haiti has very weak institutions and a very low response capacity. The Directorate of Civil Protection – the Haitian equivalent to the Dominican Civil Defense – which is the national entity in charge of civil protection in case of disasters, has roughly 22 staff members country wide. On the other hand, the Dominican Republic with population of similar size has 10 times more the number of Civil Defense staff and a network of volunteers of more than ten thousand.

2.2.4 Hurricane Jeanne 2004 (Dominican Republic - Haiti)

In September 2004 rains from Tropical Storm Jeanne affected the towns of Gonaives and Port-de-Paix in the north-west side of Haiti causing again massive floods and mudslides. About 3,000 lives were lost and 300,000 people were affected. Thousands of houses were destroyed and access roads to many villages were cut for days. The hospital and many schools and other state buildings were badly damaged or destroyed. Sizeable crops and livestock were an important part of the lost capital on both sides of the border. On the Dominican side, less than twenty people were killed, but there were about 14,000 affected people and estimated economic losses of US$250 million in lost or damaged infrastructure (ECLAC 2005). The impact of these disasters hampers all aspects of development on a disproportionate dimension.

3 RISING TIDES

Inhabiting and utilizing of the coast increased dramatically during the 20th Century, a trend that seems certain to continue through the 21st Century. Coastal population growth in many of the world's deltas, barrier islands, and estuaries has led to widespread conversion of natural coastal landscapes to agriculture, aquaculture, silviculture, as well as industrial and residential uses (Valiela 2006).

It has been estimated that 23% of the world's population lives both within 100 km distance of the coast and <100 m above sea level, and population densities in coastal regions are about three times higher than the global average (Small and Nicholls 2003).
Sixty percent of the world's metropolises with a population over five million are located within 100 km of the coast, including 12 of the world's 16 cities with populations greater than 10 million (IPCC 4AR, 2007). This includes coastal cities such as London, New York, Tokyo, Saint Petersburg and Istanbul (Nicholls et al 2004).
Among the forecasted consequences of sea-rise level that could have a direct impact on human development are land area loss, people displacement, ecosystem loss or change, economic value loss, infrastructure loss, cultural heritage loss, adaptation costs. Their intensity may differ from place to place but their spread is even.

Under the SRES[2] scenarios, the coastal population could grow from 1.2 billion people (in 1990) to 1.8 to 5.2 billion people by the 2080s, depending on assumptions about migration. Increasing numbers of people and assets at risk at the coast are subject to additional stresses by land-use and hydrological changes in catchments, including dams that reduce sediment supply to the coast.

There are more than 100 million people living within 1 m of sea level (Douglas and Peltier, 2002). These populations face a significant threat of inundation with the estimated projections of sea level rise over the span of decades.

Rising sea levels can already be observed along many shorelines including Southeast Asia. Increments of sea level rise varying from 1.75 to 2.56 mm/year have been recorded in at least 4 Vietnamese stations (Tuong 2001). Mean sea level in the Eastern section of the South China Sea (Manila Bay, Philippines) climbed by 20 cm over the 1960s to the 1990s (Perez et al., 1996)
Given the dimension of coastal plains in Asia, sea level rise is likely to become a major challenge to many Asian countries, with Bangladesh being probably the most drastic example on national scale (Warrick and Ahmad, 1996; Ali, 1996).

3.1 Megadeltas, large populations at risk

Populated deltas (especially Asian megadeltas such as the Huanghe (Yellow), Changjiang (Yangtze), Zhujiang (Pearl), Song Hong (Red), Mekong, Chao Phraya, Ayeyarwady (Irrawaddy), Ganges-Brahmaputra, and Indus etc.), low lying coastal urban areas, and atolls are key societal hotspots of coastal vulnerability, occurring where the stresses on natural systems coincide with low human adaptive capacity and high exposure.
These deltas are vulnerable to frequent geo-hazards, such as storms, floods, droughts, and sea-level rise, and recently they have been subject to anthropogenic impacts from geo-engineering projects, urbanization, and land-use changes.

Nearly 300 million people inhabit a sample of 40 deltas globally, including all the large megadeltas. This is a reasonable representation of the global population of deltas where all regions and Köppen climates[3] are represented. This sample population constitue nearly 5% of the worlds population. Average population density in the analyzed deltas is 500 people/km2 which is higher than the world's population density, with the largest population in the Ganges-Brahmaputra delta in Bangladesh, and the highest density in the Nile delta in Egypt (Ericson *et al.* 2006). These population figures are indicative of the population that can be potentially displaced by sea rise level .

Much of the population of these 40 deltas is at risk through coastal erosion and land loss, primarily as a result of the decreased sediment delivery by the rivers, but also through the accentuated rates of sea-level rise. It has been estimated that more than 1 million people will be directly affected by 2050 in three megadeltas: the Ganges-Brahmaputra delta, the Mekong delta in Vietnam and the Nile delta.

3.1.1 Regional case: the Vietnamese Mekong Delta case

Viet Nam is one of the most disaster prone countries in the world. Because of its geography and topography, the country suffers from almost all types of disasters, among the most common and severe are climate related disasters such as typhoons and floods. Between 2000 and 2006 these type of disasters have claimed the lives of 2,300 people in Vietnam, half a million have been left homeless and 15 million people have been affected (CRED EM-DAT, 2007). The Mekong Delta, the rice granary of Viet Nam and one of the most important economic regions of the country (Nguyen et al, 2000), is among the principle disaster hazard zones in Viet Nam. It is frequently affected by river flooding from upstream and typhoon storms along the coast among others. Together with the Center of Viet Nam, the Mekong Delta suffers from the greatest loss of human life and property due to yearly disasters. It is a region in urgent need of enhanced disaster mitigation and adaptation strategies (UNDP Vietnam 2002) especially with the increasing threat of rising sea levels.

Heavily populated by about 17 million people, and with a population density of 421 people/km2 the Vietnamese Mekong Delta VMD is an area rich in natural resources with 4 million hectares of fertile land, 700 kilometers of coastline and a dense network of rivers and canals (Nguyen et al, 2000). The VMD is a vital agricultural zone of the country. Since 1997 an estimated 50 percent of Vietnamese rice production comes from the VMD and in 2000 rice production constituted 78% of the land use in the VMD allowing

[3] The Köppen climate system recognizes five major climate types based on the annual and monthly averages of temperature and precipitation. Each type is designated by a capital letter: A - Moist Tropical Climates, B - Dry Climates, C - In Humid Middle Latitude Climates D - Continental Climates ,E - Cold Climates.

Vietnam to become the third largest rice exporter on the world. However, between 1 and 1.7 million hectares –25 to 44 percent of the whole VMD- are already affected by tidal flooding and salt water intrusion (Wassman, et al 2004).This has led to substantial economic losses in the agricultural sector that could get exacerbated under sea level rise.

The seasonal impacts of sea level rise on agriculture and particularly on rice crops include excessively high water level that leads to additional increase in the flooding depth that could severely hamper the performance of rice crops. Also prolonged inundation periods that may cause excessively moist conditions during the harvesting of the seasonal crops and a delay of planting for the next season. In addition, the salinity intrusion which is serious during the dry season may have adverse impacts on crops.

Given the adverse conditions of unstable flooding and moderate salinity, rice is almost the only crop that can be grown in the VMD. However, even though rice is the most important staple product in Vietnam most farmers in flood-prone rice areas are very poor. Socio economic factors are part of the situation but the combination of frequent floods, salinity and the threat of sea level rise make this enormous community very vulnerable (Wassman, et al 2004).

A GIS-based study on integrated coastal management estimated that 4 million hectares will be flooded annually in the entire country when the sea level rises by 1 m. Economic losses have been estimated to be in the range of US $17 billion for the entire Vietnam stemming from annual flooding, which is about 80% of the national GDP. It was also estimate that in the entire VMD region about 14 million people – or 82 percent of the region population would live in flood prone areas if no additional protection measures are taken (Zeidler, 1997).

In addition to the direct impacts on rice production, higher water level will make the VMD more vulnerable to extreme weather events such as storm surges and will also have an impact on natural habitats such as wetlands (Nicholls et al., 1999).

The impact of sea level rise in the VMD, has the potential to have serious consequences on the economy of the country and the stability of its 83 million people. It is also a serious direct threat to the survival of 17 million people that live in the delta and make their living out of rice production. Without appropriate adaptive capacity in the delta this threat has the potential to cause massive migration and affect the whole region.

4 WARMING SEAS IS ASSOCIATED TO CORAL BLEACHING AND FISH STOCKS

4.1 Coral Bleaching

An important aspect of the impact of rise in sea temperatures on oceans is coral bleaching. Coral bleaching is a condition that can seriously damage and kill entire coral reefs which works as supporting systems to fish and other marine organisms. Local human populations are thus placed at risk as shoreline are facing increasing erosion, fisheries stocks are becoming greatly diminished, and tourism industry can get affected. Trends of the past century and projection models suggest that coral bleaching events may become more frequent and severe as the climate continues to warm, exposing coral reefs to higher vulnerability in an increasingly hostile environment (Reaser et al, 2000).

Human populations dependent on reef service will be affected by the losses of marine biodiversity, fisheries and shoreline protection. Degradation of coastal ecosystems, especially wetlands and coral reefs, has serious implications for the well-being of societies dependent on the coastal ecosystems for goods and services. Most coral reefs are located in developing countries, and the majority of the people living near coral reefs are poor. Thus, even minor declines in the productivity of coral reef ecosystems as a result of coral bleaching events could have dramatic socioeconomic consequences for local people who depend on coral reef services (Reaser et al, 2000).
Coral reefs are strongly interconnected to fisheries, humans and therefore the economy:

- Most of the world's poor are located within the coastal zones of developing regions and many depend directly on reef species to meet their protein needs (Bryant et al, 1998).
- Although reefs cover <0.2% of ocean's area, they are host to 25% of marine fish species (Roberts et al, 1998).
- Coral reef fisheries yield at least 6 million metric tons of fish catches around the world annually excluding local subsistence fisheries (Munro, 1996)
- Coral reefs provide one-quarter of the fish catch in developing countries and employment for millions of fishers (Roberts et al, 1998).
- Much of the economic value of coral reefs is generated from tourism with net benefits estimated at nearly $30 billion annually (UNEP, 2006).
- Around 50% of the estimated 100,000 full-time fishers and several hundred thousand part-time fishers along the coast line of Eastern Africa risk losing their livelihoods if the coral reef ecosystem is degraded further (Moffat et al 1998).

The impact on the economy due coral degradation would be significant in developing countries: most island populations in the Indian Ocean and the Caribbean depend on income derived from tourism (Reaser et al 2000). For example in Dominican Republic and Jamaica tourism accounts for nearly 20% of national gross domestic product.

Coral reefs have deteriorated as a result of a combination of anthropogenic impacts such as overfishing and pollution from adjacent land-masses, (Graham *et al.* 2006; Pandolfi *et al.* 2003) together with an increased frequency and severity of bleaching associated with climate change. Coral mortality on Caribbean reefs is generally related to recent disease outbreaks, variations in herbivory, and hurricanes (Gardner *et al.* 2003; McWilliams *et al.* 2005), whereas Pacific reefs have been particularly impacted by episodes of coral bleaching caused by thermal stress anomalies especially during recent El Niño events (Hughes *et al.* 2003), as well as non-climate stresses.

Major bleaching events were observed in 1982-83, 1987-88, 1994-95 (Hoegh-Guldberg 1999) and 1997-98. Particularly severe bleaching occurred in 1998, associated with pronounced El Niño events in one of the hottest years on record (Bruno *et al.* 2001; Lough 2000).
The Global Coral Reef Monitoring Network has estimated that around 16% of the world's coral reefs were "effectively lost" in nine months during the coral bleaching events of 1997/98. The most geographically extensive and severe on record coral bleaching occurred in 1998. It was reported in at least 60 countries in the Pacific Ocean, Indian Ocean, Red Sea, Arabian Gulf and the Caribbean. A preliminary attempt to estimate the damage on the 1998 coral bleaching event in the Indian Ocean, based on best- and worst case recovery scenarios, put losses in the range of $706 to $8,190 million of 1999 (Wilkinson et al 1999).
Since 1998 there have been several extensive bleaching events. Reefs in the eastern Caribbean experienced a massive bleaching event in late 2005, another of the hottest years on record. On many Caribbean reefs, the bleaching events of 2005 exceeded that of 1998 in both extent and mortality, and reefs are in decline as a result of the synergistic effects of multiple stresses (Gardner *et al.* 2005; McWilliams *et al.* 2005).

4.1.1 Developed countries are also affected by coral bleaching

Also developed countries such as Australia and United States profit largely from coral reef related tourism as in the Great Barrier Reef and Florida respectively.
According to the IPCC TAR Australian coral reefs will experience temperatures above present bleaching thresholds almost every year, well before the end of the 21st century. The most likely outlook is that mass bleaching, leading to death of corals, will become
a more frequent event on Australian coral reefs in coming decades. For example, in 2002 bleaching occurred on much of the Great Barrier Reef (Berkelmans *et al.* 2004) and elsewhere. The loss of this ecosystem would cost Australia billions of dollars in lost revenue from tourism and fishing. Tourism on the Great Barrier Reef generates approximately $1.5 billion a year. In addition, damage to the reef could have an impact on the coastal protection it provides, resulting in further economic impact on human settlement and agriculture.

4.1.2 Climate change causes more than bleaching in coral

In addition to coral bleaching, increased concentrations of CO2 in seawater have additional impacts on this ecosystem such as ocean acidification that affects aragonite saturation state (Meehl *et al*. 2007) and reduce calcification rates of calcifying organisms such as corals (Guinotte *et al.* 2003; LeClerq *et al.* 2002). Many reefs are also affected by tropical cyclones (hurricanes, typhoons); impacts range from minor breakage of fragile corals to destruction of the majority of corals on a reef and deposition of debris as coarse storm ridges. Such storms represent major perturbations affecting species composition and abundance, from which reef ecosystems require time to recover. An intensification of tropical storms could have devastating consequences on the reefs themselves, as well as for the inhabitants of many low lying islands.
The fate of the small reef islands on the rim of atolls is of special concern. Small reef islands in the Indo-Pacific formed over recent millennia during a period when regional sea level fell (Dickinson 2004; Woodroffe and Morrison 2001). However, the response of these islands to future sea-level rise remains uncertain. There are limited data, little local expertise to assess the dangers and a low level of economic activity to cover the costs of adaptation for atolls in countries such as the Maldives, Kiribati and Tuvalu (Barnett and Adger 2003).

4.2 Fish stocks

Images of local fishermen pulling out close to empty nets from the ocean after hours of active work, are becoming more common everyday all across from Colombia to Mozambique and India. Due to the high interaction of fisheries with the economy and livelihoods of people, the effects of climate change on this ecosystem results in a direct impact on human development. Each year, oceans alone provide about 90 million metric tons of fish for human consumption (FAO). Areas highly dependent on fishing have started to suffer harsh consequences due to the variations on the ecosystem: fishing industry near bankruptcy, unemployment, food insecurity, rural-urban migration of much of the younger population and social conflicts among others.

Fishing is central to the livelihood and food security of 200 million people, especially in the developing world. Fisheries and fish production provide direct employment to 38 million people and about 100 million indirect employments. On the consumption side, fish contributes more than one-fourth of animal protein intake in Asia. In developing Asia, the risk of climate change poses additional threats to the livelihood and food security of poor households dependent on small pelagic fisheries[4].It has been estimated that around 22 million people in this part of the world obtain their livelihood from fishing (FAO, 2002) and the bulk of this are small scale or artisanal fishers in coastal areas, for whom small pelagics represent and important subset of their target species (Briones et al., 2006).

As opposed to coastal fishers in India, the Philippines and Thailand that deploy a diverse variety of gear and vessel types, artisanal fishers relying on the simplest gears and vessels are highly dependent on small pelagic fisheries (Briones et al., 2006). For example in the Philippines , small-scale municipal fishers, who legally have exclusive access to inshore waters, have to depend on small pelagics using hook and line as well as gill nets. Approximately 57 percent of the inshore fish catch in the Philippines was caught using these basic fishing tools (Trinidad, 2003). In India, small scale fishers using non-mechanized vessels are estimated to earn US$500-1200 annually per household, placing them on average well under the poverty line (Dey, 2004), therefore their adaptive capacity to changes in fish availability is minimum.

4.2.1 Country case: Ghana a former fishing nation

Ghana used to be a major fishing nation in West Africa, but the status of the fishing sector has declined over the past four decades. Ghanaians landings are dominated (93%) by small and medium size pelagic fishes and demersal[5] fishes (Perry et al., 2007). The dominant fishery sector in Ghana is the artisanal fishery conducted mostly from canoes. The number of canoes increased from about 7,000 to 10,000 during

[4] Small pelagic fisheries refer to fish that are normally caught at or near the sea surface or in the water column.
[5] Demersal fish are fish that live on or near the ocean bottom

the period of strong increase in fishery landings from 1980 to 2000 (Atta-Mills et al., 2004). However, the later decrease of fish catchments led to an increase if fishers per boat and an overall reduction in the catch per boat (from 35t in 1992 to 23t in 2001). These difficulties resulted in increased unemployment (100,000 jobs were lost in the fishing industry from 1992 to 1996) and higher mobility in and out of fishing that led to lost of skill in the industry as well as lost of control allowing for negative practices such as over exploitation and use of dynamite for fishing (Perry et al., 2007).

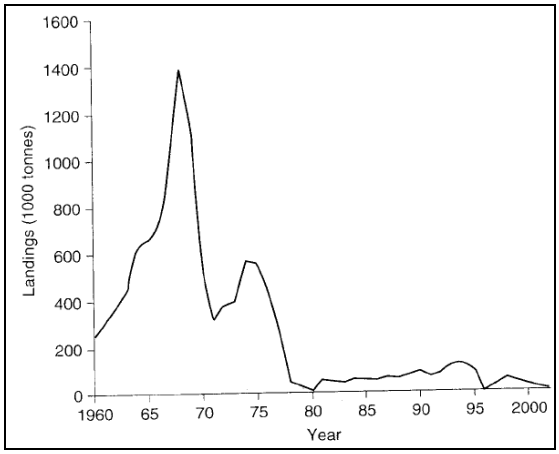
Sea surface temperature which was cool during the 1960s, warmed rapidly through the 1970s and 1980s and kept warming during the 1990s are suggestive of reducing productivity and perhaps declining stock sizes during the 1990s, in particular of pelagic species which are the main sustenance means of Ghanaian fishers. The decreasing supply of fish has led to reduced earning to the state from license and taxes, reduced spin off economic activities, leading to a declining contribution of fisheries to the GDP of Ghana (Perry et al., 2007). The contribution of the fishing sector to the Ghanaian economy has declined somewhat over the last 30 years. In 1975, fishing accounted for more than 4% of the agricultural GDP; by 1985 it had increased to 7% but by 1997 it had fallen back to 5% (Atta-Mills et al., 2004).

4.2.2 Country case: The Namibian pilchard collapse

With the warming of freshwaters like rivers, southernmost species are projected to shift northward, competing with northern species for resources. As southerly fish species move northward, they may introduce new parasites and diseases to which northern species are not adapted, increasing the vulnerability of those species. These are some of the challenges brought by the Benguela current that affect countries in the most southern west part of Africa.
It is a full reaction chain of forced fish migration due to higher ocean temperatures.
Climate change has been implicated in the observed fluctuations of small pelagic fish abundance; overfishing has amplified the threat posed by climate change by reducing fish stocks to a fragile state (Pauly 2002).

As the case of the Namibia pilchard collapse illustrates it, climate change impacts are likely to exacerbate existing strain on marine fish stocks, notably fishing pressure.
The Namibia pilchard catching rose rapidly from about 200,000 tonnes in the 1950s to a maximum reported catch of 1.4 million tones by the late 1960s when the sharp decline started to take place. In early 1970s less than 300,000 tonnes were caught and the catch went on a down hill trend varying from 0 to 25,000 by mid 1990s (Sumaila, 2006).

Figure 3 Namibian pilchard landing 1960 – 2002



Source: Sumaila et al 2006.

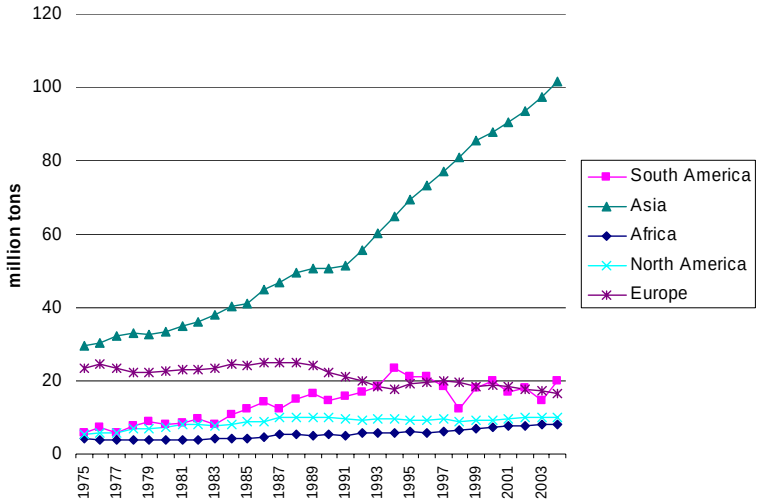
The collapse of the 1970s was largely attributable to overfishing but adverse environmental conditions such as the increasing warming of the ocean exacerbated the situation leading to unstoppable collapse in the 1990s (various authors cited in Sumaila, 2006).
In March 1995, the entire marine area from Cabinda to central Namibia was affected by the Benguela Niño[6] currents that brought anomalously warm water of up to 8°C. The fish stock forced by the advancing warm waters shifted 4-5 degrees of latitude south. This forced migration resulted in increased mortality and poor recruitment of pilchard and other species (Gammelsrod et al., 1998).

4.2.3 Overfishing, another major force depleting the ocean

The depletion of the fisheries livelihood is at expense of two major forces, climate change and over fishing. The warming is contributing to the depletion of fish stock in the north. This is resulting in massive fishing fleet moving to the pacific exacerbating the already over fished stock in the north. Industrial fishing fleets are exceeding the oceans' ecologically sustainability limits.

According to a Food and Agriculture Organization (FAO) estimate, over 70% of the world's fish species are either fully exploited or depleted. The dramatic increase of destructive fishing techniques worldwide destroys marine mammals and entire ecosystems. It is calculated that at the moment oceans are cleared at twice the pace of forests. Asia is more likely the regions with higher levels of over fishing, with capture 343% higher than 1975 (FAO).

Figure 4 World fish capture 1975-2004



Source: Data from the FIGIS – FAO Fisheries Global Information System.

Pervasive over-fishing has led to a tripling of fish harvests over the last fifty years. As a result, the majority of the world's major fisheries are now over-fished, and some have collapsed entirely. Subsidies play a role in this over-used market. Subsidies speed up the development of overcapacity and consequently threaten the continued well being of wild fish stock.

[6] Benguela Niño is thought to be a result of anomalous atmospheric conditions in the western tropical Atlantic (Boyer et al. 2000). Every year there is a southward intrusion of warm Angolan water into the northern Benguela, but during a Benguela Niño the Angola-Benguela front is displaced south, causing the advection of warm, highly saline water as far as 25°S (Shannon et al. 1986, Boyer et al. 2000). During the 1963 event temperatures off the coast of Namibia were 2-4°C higher than normal, and the pressure adjusted sea level was 4 cm above the mean. Although Benguela Niños do occur, they are less intense and less frequent than Pacific El Niños (Shannon et al. 1986).

5 MELTING GLACIERS

Glaciers are the best terrestrial indicator of climate change, due both to their sensitivity to climatic variations and the clear visibility of glacier growth and shrinkage to the public (McCarthy et al., 2001). Currently most glaciers of the world are retreating strongly as a result of global warming (Oerlemans, 2005). Reduction of fresh water in coastal zones, decrease of water supply for irrigation, lack of water for hydropower generation and loss of the tourism, are some of the ways in which glaciers melting have a human and socio economic impact.

In Alaska, 98 percent of the glaciers examined in a sweeping study of hundreds of glaciers in eleven mountain ranges show thinning, retreating or both (Molnia, 2007). A study in Peru documents glacier area loss in a section of the Cordillera Blanca –the White Mountain Range– on the order of 10% between the 1960s and 2003 (Raup et al., 2007). Area loss of 30 percent has been reported on the Kazak/Kyrgyz northern Tien Shan glacier during the last decade.

The retreat of glacier and permafrost in Asia in recent years are unprecedented as a consequence of warming. (IPCC 4AR). Glaciers in Asia are melting faster in recent years than before as reported in Central Asia, Western Mongolia and Northwest China (Pu *et al.*, 2004). Rapid melting of glaciers glacial runoff and frequency of glacial lake outburst has resulted in increased mudflows and avalanches (Bhadra, 2002).

Glaciers in Latin America are following a similar trend. Most of the South American glaciers from Colombia to Chile and Argentina are drastically reducing their volume at an accelerated rate (Leiva et al., 2006) Changes in temperature and humidity are the primary cause for the observed glacier retreat during the 2nd half of the 20th century in the tropical Andes (Vuille et al., 2003). In the next 15 years inter tropical glaciers are very likely to disappear, affecting water availability and hydropower generation. It is the case of the Chalcaya glacier en Bolivia. From 1992 to 1998, the glacier lost 40% of its average thickness and two-thirds of its total volume, and the surface area was reduced by more than 40% (Ramirez et al., 2001). At this pace, a probable extinction of these glaciers in the near future could seriously affect the hydrological regime and the water resources of the high-elevation basins of the Andes. In Peru, the White Mountain Range glacier retreat since the 19th century has triggered some of the world's most deadly avalanches and glacial lake outburst floods where nearly 30,000 people have been killed in this region since 1941 (Carey, 2005).

The externalities related to glaciers melting seem to be most pronounced in the low-latitude regions of Asia, South America and Europe where alpine-style glaciers are recognized as being particularly sensitive to the current trend of climatic warming. Within the context of developing countries, the issue of glacier melting is exacerbated by the dynamics of economic activities such as mining, hydropower and agriculture. Therefore the vulnerability is higher than in glacierised high-latitude regions (Quincy et al., 2007).

5.1 Country Case: Peruvian White Mountain Range - the response of tropical glaciers to climatic forcing

Following a global climate trend, tropical glaciers have strongly retreated during the 1980s and 1990s and are close to vanish entirely in some parts of the tropical high mountains (various authors cited in Kaser et al 2003). Besides their crucial role in regional water supply tropical glaciers are also highly sensitive indicators of the variations of climate (Kaser et al 2003).
Peru contains more than half of the world's tropical glaciers. Most of the country's glaciers are located in the Cordillera Blanca: ~600 glaciers in this range cover approximately 620 km^2, making it the most glaciated tropical mountain range in the world (Kaser and Osmaston, 2002; Georges, 2004). The Andes mountains have lost at least 22 percent of their glacier area since 1970 and the melt is speeding up (IRENA, 2007). The White Mountain Range's glaciers retreating has been more pronounced and more rapid retreat since the 1980s (Kaser and Omaston, 2002).

Retreating glaciers have led to the formation of precariously dammed glacial lakes as well as to the thinning and fracturing of glaciers. The number of glacial lakes has risen dramatically from 223 in 1953 to 374 in 1997. This lakes increase the vulnerability to disasters since when glacier melting avalanches or

landslides crash into these lakes the ensuing waves can rapidly erode moraine dams and trigger outburst floods (Carey, 2005). In fact these glacial lakes have generated at least 24 outburst floods in the past 150 years and the unstable glaciers have produced at least six avalanches killing nearly 30,000 thousand people since 1941 (Zapata Luyo, 2002). The reported outburst floods and avalanches have caused varying degrees of damage over the years, from killing livestock and destroying crops to destroying infrastructure such as a hydroelectric station and devastating cities and killing thousands of people (various authors cited in Carey, 2005).

The population at risk is half a million people that live directly below the White Mountain Range's glaciers and glacial lakes. This population consists of rural indigenous people and urban mestizos. Aside from increased disasters risk due to glaciers melt, future water supplies to the arid coast were most Peruvians live is endangered.

The water runoff from the glacier is used in various economic activities before reaching the ocean. It is the lifeline of the region starting from the intensively cultivated Callejon de Huaylas to hydropower production in the Cañon del Pato to agriculture and industry in Rio Santa valley right before reaching the Pacific coast. The increasing vulnerability in this area is a consequence of natural and man-made factors. First of all climate warming has accelerated the melting pace of the glaciers. Secondly, the population in the different regions neighboring the glaciers has increased between a 50 and a 70 percent since 1970s (currently 1.2 million people). Human activities and lifestyle have also changed dramatically with an increased consumption of energy and fresh water and intensification and modernization of agriculture as well as mining activities (Kaser et al. 2003). The intensification of water runoff might be favourable for current agricultural activities, but in the long-run the region might face water shortages.

The accelerated melting of glaciers pose a wider range risk since glaciers feed the rivers that feed the over populated sprawling cities and shantytowns on Peru's dry Pacific coast. They also serve hydroelectric plants that generate 70 percent of the country's power. This rapid glaciers meltdown can provide abundant hydroelectric energy to Peru, but this water bonanza might not last beyond 2050.

6 HEAT-WAVES AND COLD SPELLS

Episodes of extreme heat or cold have brought higher mortality in the past 30 years.
There is evidence of recent increases in mean surface temperatures and in the number of days with higher temperatures, with the extent of change varying by region.
Cold waves continue to be a problem in higher latitudes where very low temperatures can be reached in a few hours and extend over long periods but also an increasing problem in lower latitudes and warmer climate countries such as in sub tropical South east Asia where the population is not used to extreme low temperatures. In general, high-income populations have become less vulnerable to both heat and cold. Studies in Europe and in the United States of mortality over the past 30 to 40 years found evidence of declining death rates due to summer and winter temperatures. Declines in winter mortality are apparent in many developed countries primarily due to increased adaptation capacity to cold but the situation is not the same in developing countries where the capacity to adapt to sudden weather changes can not be made readily available. On the other hand, the mortality associated with extreme heat waves has not declined.

Heat and cold waves cause enormous losses in terms of human discomfort economic impact. In general this type of disaster are a rare occurrence as compared to the frequency of other disasters such as floods, cyclones, storms, etc. but the magnitude of their impact can be similar to those especially regarding the time that take the affected population to recover from them.

6.1 Extreme temperatures - concerning trends

Extreme temperatures, both heat waves and cold spells, are killing fifty times more people nowadays than thirty years ago. The number of people killed by heat waves between 2000 and 2006, for example, reached 52,000 while during the whole decade of the 1970s this figure was around 800 people. Even though the human costs of cold spells are not as high as heat waves, it has also increased 20-fold in the last 35 years from around 300 people being killed by cold waves in the 1970s to almost 7,000 between 2000 and 2006.

Figure 5 People killed by heat waves and cold spells from 1970 to 2006.

Data source: CRED EM-DAT (2007)

6.2 Heat waves

Extreme temperatures have become a real threat to millions around the world, and an unprecedented pattern is that people in rich countries have been hit harder. The 25-30,000 deaths attributed to the European heat wave of the past five years is greater than that observed in the last century in Europe (Kosatsky 2005). Since the observed higher frequency of heat waves is likely to have occurred due to human influence on the climate system, the excess deaths of the 2003 heat wave in Europe are likely to be linked with climate change (IPCC AR4, 2007)
There were also eighteen heatwaves reported in India between 1980 and 1998, an unprecedented trend, with a heatwave in 1988 affecting ten states and causing 1,300 human deaths. Heatwaves in Orissa, India, in 1998 and 2003 caused an estimated 3,800 deaths. The highest single number of deaths due to heat waves during the XXth century 2,540 (CRED,2007) was reported by India in 1998.

The damage resulting from heat waves often includes losses of agricultural products and livestock. This is a great cause of food insecurity, hunger and bankruptcy among farmers. Power cuts and failures due to water shortage as well as insufficient supplies of drinking water are also caused by heatwaves. India, Pakistan and Bangladesh are particularly susceptible to heatwaves given their geographic location and socio economic conditions.

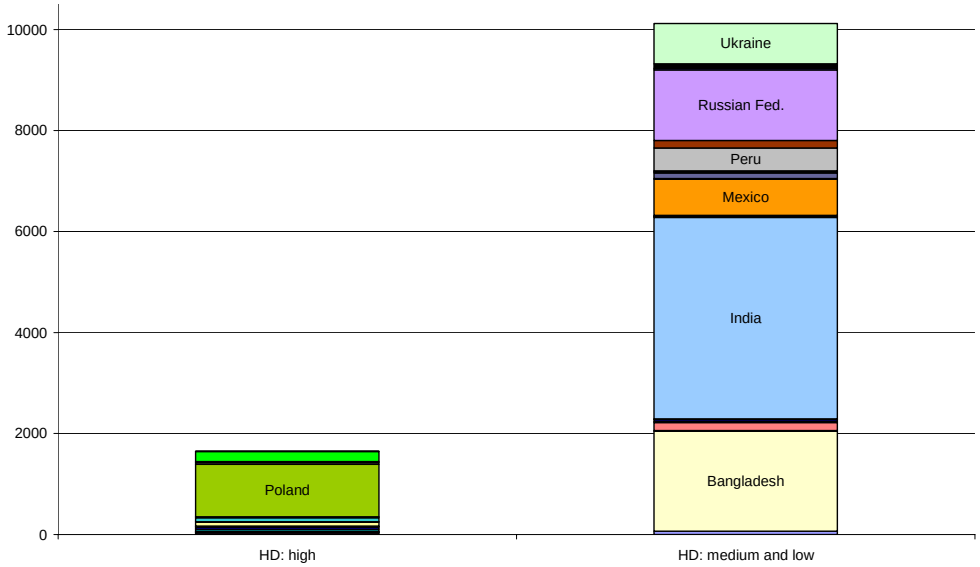
6.3 Cold spells

Cold spell catastrophic news come from all over the world, north and south, rich and poor. In 2003 an unexpected cold spell killed at least 400 people in northern India and 200 more in January 2006. In that same month other 800 people were killed in Ukraine due to freezing temperature reaching minus 30 degrees Celsius and almost 5,000 were hospitalized. In parallel in Bangladesh at least 150 people were reported death due to the cold wave that hit the northern districts. Poland has seen more than 4,000 people killed in the last 2 years due to unusual harsh winters with temperature below 35 degrees Celsius.
In general, population sensitivity to cold weather is greater in temperate countries with mild winters, as populations are less well adapted to cold.

Cold waves carry with it a combination of meteorological factors, extremely low temperatures, heavy snow falls, icing, dense fog, high wind speeds, severe precipitations, blizzards, frosts, etc. Such a combination affects not only human health but the agricultural systems and seriously threats livestock.

The risk is spread evenly but the vulnerability is not. Richer countries are less vulnerable than developing countries to harsh weather given their higher capacity to adapt. In fact, the biggest number of victims from cold spells is from developing countries. An estimated 86% or 10,000 of the people killed by cold spells between 1975 and 2006 live in countries ranked in the medium and low human development range with countries such as Russia, Bangladesh and India on top of the list with the highest number of victims. On the other hand an estimated 14 percent or about 1,700 of the people killed by this type of natural disasters are in the high human development range.

Figure 6 Number of people killed by cold waves between 1975 and 2006 – by level of human development



Data source: CRED-EM-DAT, 2007 and HDR 2006

Cold spells may also kill livestock massively. Recent cases such as the cold spell in January 2007 killed over 5,000 cattle in Northern Mexico, same month when the state of Colorado in USA saw 10,000 animals being killed by below zero temperatures and higher impact cases like in Mongolia where catastrophic cold spells killed millions of livestock leaving almost a third of the country in despair are becoming more common over the years.

6.3.1 Country case: Mongolia *dzud*[7] case

Mongolia has reasons to be concerned about climate change. The country's vast population depends on livestock and other climate dependent sectors. The sub-sector of animal husbandry plays a major role in national economy: employs 47.9 per cent of the total population, produces 34.6 per cent of agricultural gross production and accounts for 30 percent of the country's export (Batima et al 2005).

In the winter of 1999-2000 more than 3 million heads of livestock perished. It was a winter disaster, called *dzud* in the Mongolian language. The causes of this *dzud* were drought during the summer of 1999 followed by extreme winter weather conditions. The 1999 – 2000 dzud caused an estimated US$84 million in damage to the Mongolian economy overall. Additionally, almost half a million herders were affected and

[7] A *dzud* is a name given in Mogolian language to the winter natural disaster that involves mass debilitation and death of livestock due to starvation and/or extreme cold.

2,400 families (about 12,000 people) lost all their livestock, their means of livelihood (Hadrill, 2001). The following winter of 2000-2001 Mongolia experienced its worst winter disaster in more than 50 years killing 4.2 millions of livestock, or 13% of the national herd of livestock in this predominately pastoral country. Snows up to 90 cm deep in the northeastern provinces of Zavkhan and Uvs, temperatures as low as minus 49°C and wind speeds of more than 100 kph were reported.

The factors precipitating the emergency included weather, transition of the economy, government structural weakness and over-grazing (Hadrill, 2001). Re-stocking that has been one of the short term solution is just contributing to increasing vulnerability given the potential for further over-grazing.
In 2000 the total livestock was over 29 million. By 2003 it had dropped to 25 million, a 14% decrease. The country is still struggling to recover from it. Vulnerability has increased at the household level, due to absolute dependency on privately owned livestock, new experienced herders and low income. Therefore, at the household level the impact has been devastating; destitution of families that lost all their animals, shortage of milk and dairy product for daily diet – putting at risk children's nutrition, loss of transport and herding capabilities by losing riding horses, low birth rates of animals as many pregnant animals aborted due to freezing temperatures – leading to delays in recovery from livestock losses, etc.
Negative impacts and magnitude of the Mongolian dzud are comparable to the most drastic droughts hitting the horn of Africa: loss of life, livestock, livelihoods, property, as well as dwindling supplies of pasture, water and food. Dzud are shorter in time but as intense as droughts in terms of human and animal casualties and losses.
Dzud in fact is a recurring natural disaster specific to Mongolia. Between 1945 and 2001, Mongolia suffered a total of 8 major *dzud* years that killed between 2 and 12 percent of the entire Mongolian herd of animals.

Table 1 Estimates of Losses of Livestock to Winter Calamities (1944–2001)

Years	Type of disaster	Losses Adult Livestock (head)	Losses Young Livestock (head)
1944–1945	Drought and dzud	8,100,000	1,100,000
1954–1955	Dzud	1,900,000	300,000
1956–1957	Dzud	1,500,000	900,000
1967–1968	Drought and dzud	2,700,000	1,700,000
1976–1977	Dzud	2,000,000	1,600,000
1986–1987	Dzud	800,000	900,000
1993	Dzud	1,600,000	1,200,000
1996–1997	Dzud	600,000	500,000
1999–2000	Drought and dzud	3,000,000	1,200,000
2000–2001	Drought and dzud	3,400,000	n/a
Total		**25,600,000**	**9,400,000**

Source: Suttie, J.M. 2001, Herding Risk in Mongolia. Association, Scottish & Borders Branch, November 2001. UNDP project MON/02/305

As the patterns of climate change in Mongolia show climate is warmer and slightly drier and precipitations have tended to decrease slightly. The number and duration of hot days is increasing (Batima *et al*. 2005). All these are contributing factors to more frequent droughts that end up in the winter disaster called *dzud*. Harsh and long lasting summer drought is the main factor leading to harsh *dzud* during winter time. Mongolia experienced in 1998 the warmest year of the last century with duration of the heat wave reaching 70 days in the high mountains and 30 days in the Gobi desert. This apparently led to four consecutive years of drought that contributed significantly to the catastrophic *dzud*. Mongolia experienced its worst droughts in the summers of 1999, 2000, 2001 and 2002, which affected 50-70% of Mongolian territory. About 3,000 water sources including 680 rivers and 760 lakes dried up during these long-lasting droughts (Davaa, 2004). Climate patterns of the last 30 years also show that snowfalls are starting earlier and lasting longer

(Batima *et al*. 2005). Summer drought of 1999-2002 caused the most severe *dzud* in recorded history in the winters of these years (Natsagdorj 2002)

In a country like Mongolia where more than 30% of the population depends on livestock for all this is a serious threat for survival. Mongolian nomadic herders who make up about a third of the country's population depend on livestock- for food, clothing, trade and transportation (UNDP, 2002). Thinning herds means starvation or increased poverty for a large proportion of the country's population.

Even with the best of preparations, many of Mongolia's herding families would have suffered. However, man-made factors also contributed to the impact of these *dzud*. Foremost among these, and especially during the summer and fall of 1999, preparations for the impending *dzud* were inadequate. Although Mongolia's Hydrology and Meteorology Research Institute (HMRI) provided adequate warnings of the harsh winter ahead, preparations by the Government and the herders themselves were in most cases too little and too late. For example, although the State Standing Emergency Commission (SSEC) advised the Government of the threat of *dzud* as early as August 1999, a
Government resolution to allocate funds for purchase of 3,400 tones of hay for feeding of livestock was not issued until late October; and the hay was not actually delivered until February 2000. For many herders and their animals, already weakened by inadequate grazing during the summer months and extreme cold during the winter months, the hay was too late (UNDP, 2002)

7 THE SPREAD OF DISEASES

Human beings are exposed to climate change through changing weather patterns and indirectly through changes in water, air, food quality and quantity, ecosystems, agriculture, livelihoods and infrastructure. The direct or indirect exposure to these factors can cause disease, disability and death. A population with high rates of disease is more vulnerable to climatic changes and less capable to progress and escape poverty.

Climate can affect health through several mechanisms:

- Extremes of temperature, such as heat waves and cold spells, and rainfall variability that cause floods and drought, have direct immediate effects on mortality as well as longer term effects,
- Changes in temperature and rainfall may also affect the distribution of disease vectors, e.g. those that transmit malaria and dengue, as well as the incidence of diarrhoeal diseases,
- Climate can affect levels of air pollutants, for example tropospheric ozone pollution may be higher in some areas of Europe, and lower in others,
- Sea level rise is likely to threaten low lying coastal populations, particularly in countries with low adaptation capacity,
- Biodiversity is also likely to be affected by climate change thus affecting the ecosystem goods and services that we rely on for human health (Haines et al 2006).

Observations of short-term variations in climate or weather show that even small temperature increases and precipitations changes can result in measurable impacts on malaria, diarrhoeal episodes, injuries related to floods and malnutrition (Haines et al., 2006). The relationship between short-term climatic variations and occurrence of infectious disease – especially vector borne disease – has been documented in various regions (McMichael, *et al* 2006). Studies in Venezuela and Colombia have reported the association of malaria outbreaks with El Niño events (Bouma et al 1997). In the Asia Pacific region, el Niño and la Niña events seem to have affected the occurrence of dengue fever outbreaks (Hales et al 2002). Changes in the intensity of El Niño cycle since 1975 and more recently its frequency –both probably manifestations of climate change –have been accompanied by a strengthening of the relation between that cycle and cholera outbreaks in Bangladesh (Rodo et al, 2002).

Since global temperatures have risen noticeably over the past three decades, some health outcomes are likely to already have been affected. However, the detection of health effects due to climate change is at this stage difficult. The complexity of some causal pathways makes attribution difficult. For example, along with short-term climate variability, many environmental factor affect malaria incidence, including altitude, topography, environmental disturbance. To make a quantitative attribution of change in incidence to any single factor is therefore difficult (McMichael, 2006).

With medium to high degrees of confidence, the scientific community has established that climate change has altered the distribution of some infectious disease vectors, as well as the distribution of some allergenic pollen species. It has also increased the risk of heatwave related deaths.

Among the impacts of climate change-related exposure on human health are the increase malnutrition and consequent disorders, including child growth and development, increase the number of people suffering from disease and injury due to heatwaves floods, storms, fires, and droughts, mixed effects on malaria; in some places the geographic range will contract, elsewhere the geographic range will expand and the transmission season may be extended, increase the burden of diarrhoeal diseases, increase the frequency of cardio-respiratory diseases due to higher concentrations of ground level ozone and increase the number of people at risk of dengue.

Climate change is also expected to bring some benefits to health, including fewer deaths due to exposure to the cold, but it is expected that these will be outweighed by the negative effects of rising temperatures worldwide. The overall balance of effects on health is likely to be negative and populations in low income countries are likely to be particularly vulnerable to the adverse effects.

Adverse health impacts will be greater in low income countries, but as the experience of the 2003 heat wave in Europe shows, high-income countries may also be adversely affected. Mortality rises in hot weather, especially in elderly people. It is very likely that climate change will be associated with increases in the frequency of heatwaves (Huem et al 2002). Those at greater risks in all countries include the urban poor, the elderly and children, traditional societies, subsistence farmers and coastal populations.

7.1 Malaria, an increasing disease burden

The world is facing a rapidly increasing disease burden of malaria. Many factors have been attributed to it including long-term climatic changes such as more pronounced El Niño cycles and global warming, but also other factors such as populations movements to malarious regions, changing agricultural practices including the building of dams and irrigation schemes, deforestation and the weakening of health systems in poor countries among others (Sachs et al., 2002).

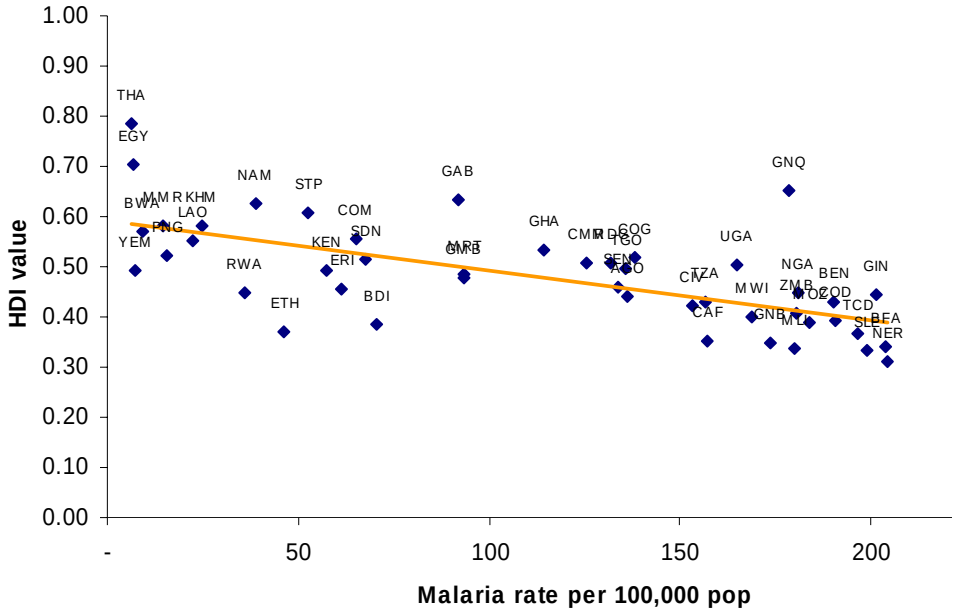
Malaria is the disease with highest morbidity and mortality worldwide. It is the most disabling vector-borne disease globally. Some 40% of the world's population is at risk of contracting malaria and about 75% of cases occur in Africa. In 2004 malaria claimed the lives of 1.3 million people, 90% of them children under the age of five.

As climate changes, warming and weather extremes are likely to play expanding roles in the spread of malaria Warmer temperatures speed up the maturation of the malaria parasites inside the mosquitoes. At 20^{o}C for example it takes 26 days to incubate while at 25 ^{o}C, the parasites develop in half the time (McMichael et al.2002).
The incidence of malaria is higher among populations living at lofw latitudes and increasingly in highland areas in Africa.
Preventing deforestation is the most significant environmental intervention for limiting the spread of malaria. Deforested areas are prone to flooding and habitat fragmentation increases mosquito-breeding sites while removing sites for predators such as larvae-eating fish and mosquito-eating bats (CHGE-Harvard Med School, 2005). For example in the Caribbean region, the country with highest incidence of Malaria is Haiti and it is the country with highest deforestation – only 3 percent of the country area is covered by forests.

Where malaria prospers most, human societies have prospered least (Sachs et al 2002). There is a clear negative correlation between malaria and development and an intimate relation between malaria and poverty. The global maps of malaria and poverty mirror each other. Both poverty and malaria are highly concentrated in tropical and sub-tropical areas (Sachs et al 2002). The same areas that are facing higher climate change related risks, and lower adaptive capacity.

As seen on the graph below, countries with the lowest levels of human development such as Niger, Burkina Faso and Guinea present the highest levels of malaria mortality.
On the other hand, countries with medium levels of human development such as Thailand and Egypt present lower levels or malaria mortality rates.

Figure 7 Estimated deaths caused by Malaria per 100,000 population and HDI value



Data source: WHO Global burden of disease 2004 and HDR 2006.

The same way a country's GDP influences malaria risk, malaria has been shown to decrease economic growth and therefore development. In severely malarious countries there have been reported a decrease of 1.3 growth rate percentage points per year (WHO 2001). Changes in climate pose an additional challenge for poor countries to control the burden of malaria. It is a vicious cycle made worst by climatic changes. The economic development necessary for improvements in the public health infrastructure is directly hindered by the presence of malaria itself and it is made worst by increasing trend of extreme weather events.

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