

# We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

186,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index  
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?  
Contact [book.department@intechopen.com](mailto:book.department@intechopen.com)

Numbers displayed above are based on latest data collected.  
For more information visit [www.intechopen.com](http://www.intechopen.com)



# Mainstreaming Climate Change for Extreme Weather Events & Management of Disasters: An Engineering Challenge

M. Monirul Qader Mirza

*Adaptation & Impacts Research Section (AIRS), Environment Canada  
c/o-Department of Physical and Environmental Sciences  
University of Toronto at Scarborough  
Toronto  
Canada*

## 1. Introduction

World climate and sea level are changing. The decade of 2000-2009 was the warmest in modern record (NASA, 2010). In the period 1905-2006, global mean surface temperature has increased by three-quarter of a degree Celsius. Ocean temperature has also risen. Overall, global land precipitation has increased but there is no spatial or temporal uniformity. More intense and longer droughts observed in the tropics and sub-tropics. Large scale decreases in melting of glaciers and ice caps were recorded that had contributed to global sea level rise. Average temperatures in the Arctic increased at the rate as twice as the rest of the world in the past century but there were regional variations. Future projections are a warmer world with more extreme temperature episodes, intense precipitation activities, likelihood of increased intense tropical cyclone activity and expansion of area affected by droughts (IPCC, 2007).

Climate change will pose a formidable challenge to the engineering society in particular. Since the dawn of civilizations, engineers built infrastructure to protect human society and property from the onslaught of natural hazards. Despite failures in many occasions which contributed to disasters (however, failure of structures alone cannot cause disasters; there must be the other socio-economic and human factors), engineering infrastructures indeed saved lives and property and contributed to human-well being. Changing climate can increase occurrence of more extreme weather events as well as their intensities may increase (IPCC, 2007). Infrastructures built with only the consideration of historical risk may be inadequate to provide the required protection. Many engineering projects are being undertaken now will experience climate change in their life cycle. Therefore, it is an imperative to mainstream additional climate risk in planning, design and implementation of engineering infrastructures to provide safety. It is not an easy task. There are many challenges ahead.

## 2. Overview of natural hazards and disasters

### 2.1 Is frequency increasing?

Is frequency of extreme weather events increasing? By analyzing data from 1980 to 2010, Munich Re (2010) concluded that there was a gradual increase in hydro-meteorological

extreme events worldwide. Many of the recent extreme events have left behind trails of devastations. Particularly two hydro-meteorological events that occurred in 2010 deserve discussion. Pakistan and Russia experienced flood and wildfire of disproportionate nature in 2010. About 1800 people lost their lives and six millions were made by the floods in *Pakistan*. The devastating floods started in the north-west of the country in the basins Swat and Kabul Rivers and gradually traveled to the south through the Indus River. Most of the gauging stations displayed record breaking water levels since the continuous measurement began in 1947. The country incurred an economic loss of US\$ 9.5 billion (Munich Re, 2010; ADB, 2011). *Russia* witnessed doubling of the number of wildfires and the area affected from 1985 to 2004. Two major factors-extreme dryness and heat contributed to the outbreak of fires in the 2010 summer. In July, the observed rainfall in Moscow was just 12 mm or 13% of the normal. The July and August temperatures were the highest in the recorded history of 130 years. The flames were additionally fanned by strong winds (Munich Re, 2010). The fires killed 130 people directly. However, indirectly an estimated 56,000 people died due to an increase in the number and intensity of heart attacks, strokes, asthma attacks and bouts of coughing, as well as skin and eye disorders. Economic and insured losses were \$3.6 billion and \$20 million, respectively from the wildfire events (Munich Re, 2010).

Although globally extreme hydro-meteorological events are on the rise, but there are regional variations in of their categories. In the north Atlantic region, no increasing trend was found in hurricane frequency (BAMS, 2000). Singh *et al.* (2000) studied changes in the frequency of tropical cyclones developing over the Arabian Sea and the Bay of Bengal utilizing 122 years (1877-1998) of data. They revealed significant increasing trends in the cyclone frequency over the Bay of Bengal during November and May which are main cyclone months. Analysis of long-term flood data in the Ganges, Brahmaputra and Meghna basins in India, Bangladesh and Nepal did not show any general increasing or decreasing trend (Mirza *et al.*, 2001).

The North-Atlantic hurricanes and typhoons have become stronger and longer-lasting since 1970s (Emanuel, 2005). Since 1949, the annual average storm peak wind speed summed over the North Atlantic and eastern and western North Pacific increased by 50%. The duration of storms also increased roughly by 60%. Both duration and peak intensity of trends contribute to the overall increase in net power dissipation. In a recent paper, Pielke Jr. *et al.* (2005) found no precise causation for this trend. Analyses conducted by Landsea *et al.* (1999) and Chan and Liu (2004) could not identify any secular trend in tropical cyclone intensity in both Atlantic and North Pacific, respectively. Lal (2001) detected increased intensity of cyclones in the Bay of Bengal region.

## 2.2 Are damages on the rise?

Globally economic damage from extreme natural events is on the rise (**Figure 1**). Munich Re (2010) estimated overall economic loss of about \$150 billion in the year 2010 of which extreme weather hazards accounted for more than two-thirds of it. Previously, Munich Re (2004) estimated that economic losses increased by seven folds in the period 1994-2004 compared to that of 1960-1969. The main reason behind huge economic losses is economic development in the areas under risks of natural extreme events. The human population has increased (more than doubled) since 1960s, and that these increase are especially intense in the developing countries. However, in the same period, insured losses were increased by 15 folds. This is due to the expansion of insurance business, coverage and higher rate of claims.

Date	June-July	December	July-August	September	Summer
Country/ Region	China	Australia	Pakistan	Mexico	Russia
Event	Floods - landslides	Floods	Floods	Hurricane Karl Floods	Heatwave, drought, wildfires
Fatalities	>800	-	1760	16	Direct: 130; indirect:56, 000
Economic Losses (US\$m)	15,000	>10,000	9,500	3,900	3,600
Insured Losses (US\$m)	270	>5,000	100	150	20

Source: Munich Re, 2010

Table 1. Five Largest hydro-meteorological catastrophes Occurred in 2010

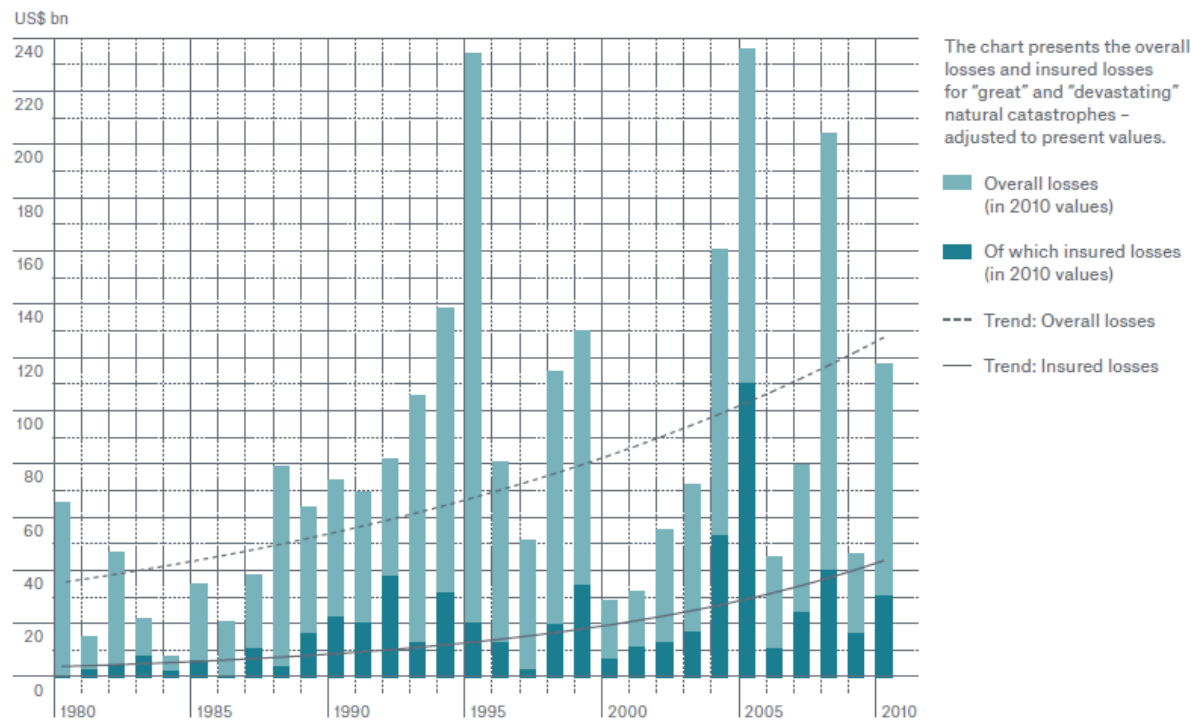


Fig. 1. Economic losses and insured losses – Absolute values and long-term trends. Source: Munich Re, 2010.

Any extreme event has a long term effect on insurance industry as well on the clients. For example, after Hurricane Andrew, a number of insurance companies in the USA went bankrupt because the number and amount of claim were so high (Changnon *et al.*, 1996).

The rate of premium goes up for both the insurer (re-insurance) and the policy holder. The reinsurance prices nearly doubled (CBO, 2002).

### 3. Climate change & future hazards

Based on the analysis of observed temperature records, the IPCC's Fourth Assessment Report concluded "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. (IPCC, 2007., p.5.)" In different time-periods of the 100 years (1905-2006), the rates of warming are showing an upward trend. For example, from 1955-2005, the rate of temperature increase per decade was 0.128°C. But from 1980-2005, the rate has increased to 0.178°C per decade. The mid- and high latitudes of the Northern Hemisphere demonstrate the largest rates of warming. The evaluation also indicates significant warming of sea surface temperature in the extra-tropical North Atlantic since the mid-1980s. Although sea surface warming is assumed to be associated with the warming phase of natural cycle (Folland *et al.*, 1986; Delworth and Mann, 2000), global warming is likely to be a contributing factor (IPCC, 2007). Changes in the amount, intensity and type of precipitation occurred which exhibited large natural variability as well as influenced by El Nino and the North Atlantic Oscillation. Observational records from 1900-2005 demonstrated significantly wetter in eastern North and South America, northern Europe and northern and central Asia. On the other hand, drier conditions observed in the Sahel, southern Africa, the Mediterranean and parts of southern Asia. In the northern regions, the amount of rain exceeded the snowfall. Heavy precipitation events increased significantly even in places where the total amount of precipitation displayed a reduction. Some regions also experienced occurrences of both floods and droughts (IPCC, 2007).

Knowing that global surface temperatures and precipitation patterns are changing, one question posed by the IPCC Third Assessment Report asks if and how climate variability or climate extremes have changed. The answer to this question is difficult to achieve since each climate variable is described by a different statistical distribution, which in turn exhibits case by case interactions between the changes in mean and variability. **Figure 2** illustrates this concept in terms of temperature. As the mean temperature increases, so does the occurrence of high temperatures (**Figure 2a**). As the variability increases, so does the probability of occurrence for both hot and cold extremes as well as the absolute value of the extremes (**Figure 2b**). Increases in both the mean and the variability can exacerbate the increase or decrease in probability of either hot or cold extreme temperatures (**Figure 2c**). The problem is further complicated by the presence of non-linear relationships between changes in one variable on another variable. For example, changes in mean temperatures correspond with changes in extreme weather events (Wigley, 1985; Wigley, 1988; Meehl *et al.*, 2000).

As part of the IPCC's Fourth Assessment Report (2007), the changes in variability and extremes for temperature and precipitation were evaluated simultaneously. The results from limited regional studies suggest that variations in temperature on both intra-seasonal and daily time-scales are decreasing. Thus, increases in global temperatures are influenced mainly by a significantly reduced frequency of extreme temperatures that are below normal supplemented by a smaller increase in the frequency of extreme temperatures that are above normal. More specifically, studies by Frich *et al.* (2001) show a reduced number of days with frost across much of the globe with a corresponding increase in heat-wave frequency in the Northern Hemisphere and Australia. The results are illustrated in **Figure 3**. The Frich *et al.* (2001) study also suggests an overall increase daily rainfall intensity with certain regions



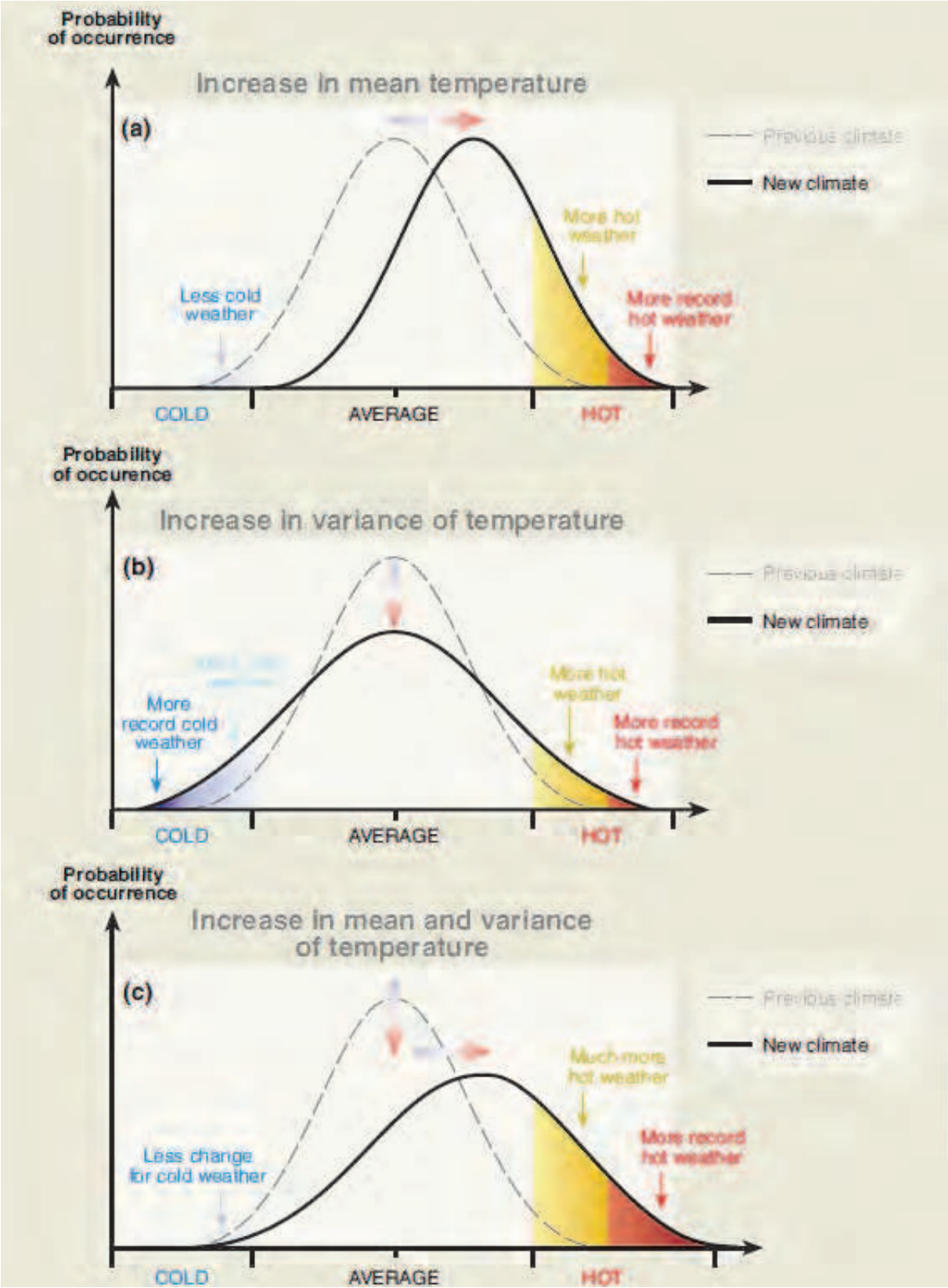


Fig. 2. Schematic showing the effect on extreme temperatures when (a) the mean temperature increases, (b) the variance increases, and (c) when both the mean and variance increase for a normal distribution of temperature (Source: IPCC, 2001a).

experiencing increases in both the proportion of mean annual total precipitation falling into the upper five percentiles and in the annual maximum consecutive 5-day precipitation total. This is illustrated in **Figure 4**. The results published by Frich *et al.* (2001) were verified and updated by Alexander *et al.* (2006). The new study focused on changes in extreme events and included data for most of Central and South America, Africa, and southern Asia, which was previously absent. The project also led to the development of a more comprehensive and appropriate suite of climate change indices and a user-friendly software package for analyzing the indices and creating seasonal time series from the results.

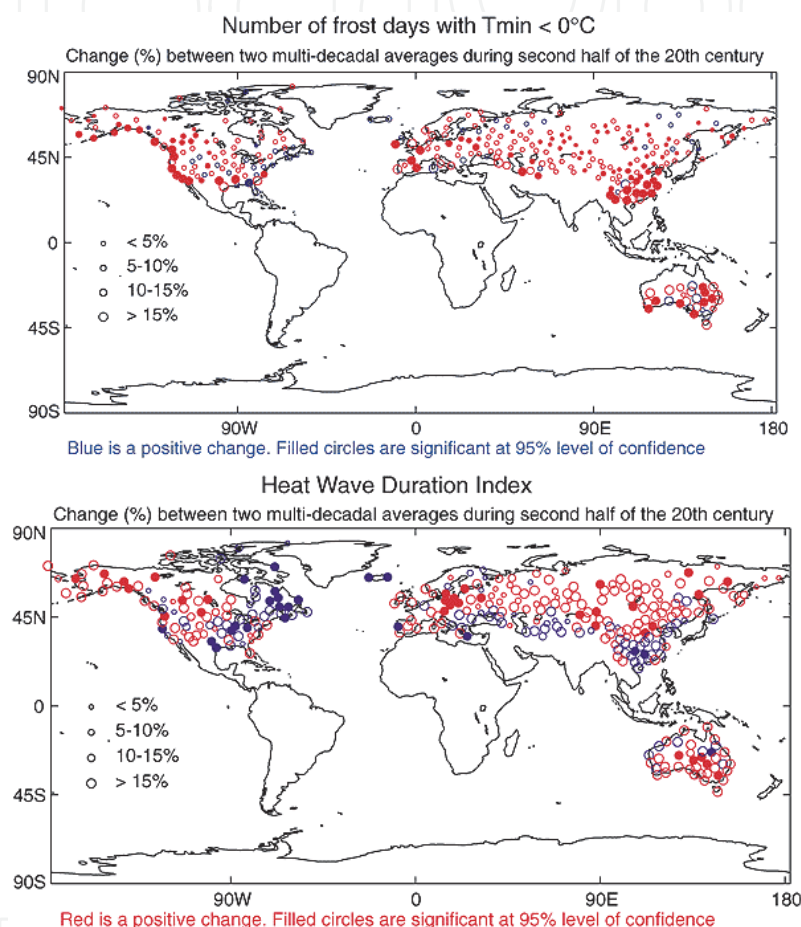


Fig. 3. Changes in the number of frost days and in heat-wave duration between the first and last half of the period 1946 to 1999 (Source: Frich *et al.*, 2001, cited in IPCC, 2001a).

The AR4 of the IPCC (2007) also included analyses of data related to changes in extreme weather and climate phenomena. For example, regarding the tropical cyclonic activity, the report concluded about intensification in the North Atlantic region since 1970 and that was correlated with increases with tropical sea surface temperatures. Although the intensification of cyclonic activities has been identified in some other regions, the IPCC (2007) expressed concerns about the quality of the data. In light of the difficulties involved with determining trends in climate variability and extreme events, numerous studies based on appropriate statistical analyses are being carried out. For example, Webster *et al.* (2005) have published studies that suggest an increase in hurricanes in the Atlantic basin, as well as a higher percentage of more intense ones. These results are illustrated in **Figure 5**.

However, a review by Michaels (2005) disputes these conclusions and suggests that increases in tropical storms can actually be attributed to natural cycles. Extending the starting point for analyzing observed hurricane data from 1970 to 1945 reveals a bigger picture that shows an oscillatory pattern of active and inactive periods rather than an increasing temporal trend (**Figure 6**). In a recent research results, Saunders and Lea (2008) concluded that tropical cyclonic activity in the Atlantic was related to sea surface temperature. They found a statistical relationship that 0.5°C increase in sea surface temperature increases cyclonic activity by 40% in August-September. Although it is acknowledged that increases in tropical storm intensity can be related to increases in sea surface temperature, consideration should also be given to other factors that determine the ability of the tropical cyclones to attain Category 4 and 5 intensities (Pielke, 1990, 1997).

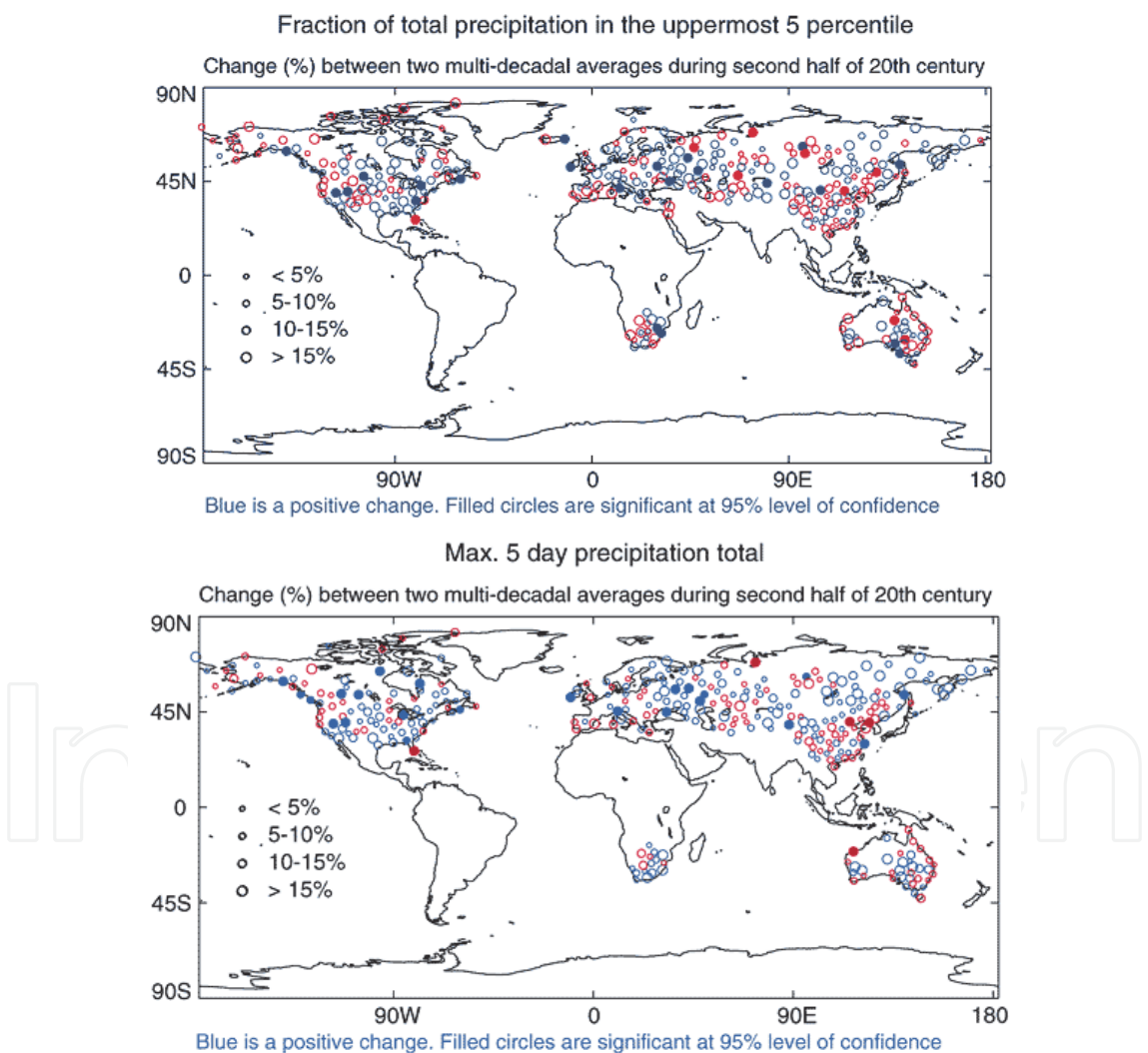


Fig. 4. Changes in the proportion of annual precipitation occurring on days on which the 95th percentile of daily precipitation, defined over the period 1961 to 1990, was exceeded and the maximum annual 5-day precipitation total between the first and last half of the period 1946 to 1999 (Source: Frich *et al.*, 2001, cited in IPCC, 2001b).



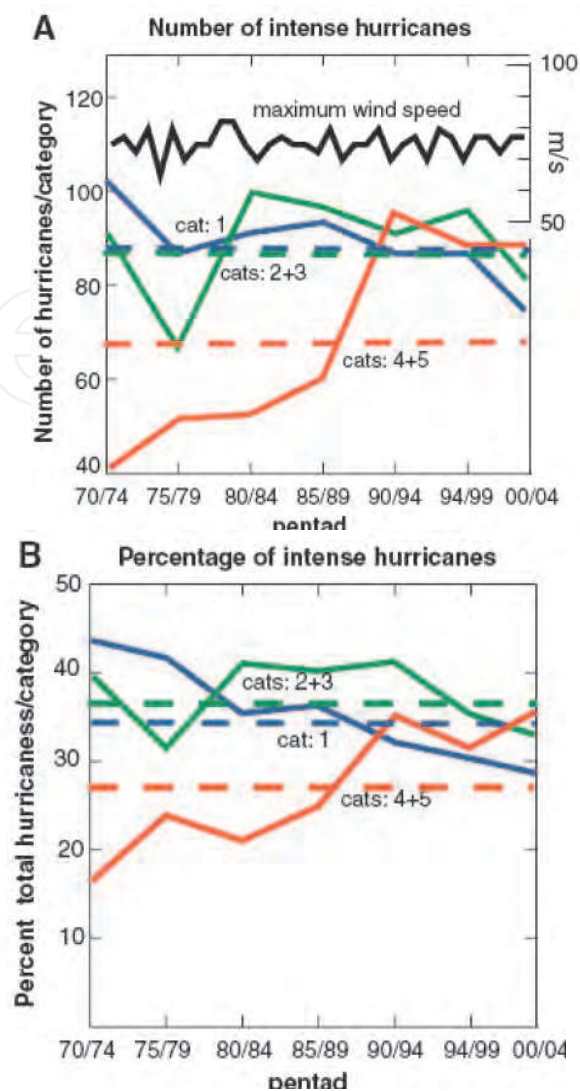


Fig. 5. Total number of storms (a) and percentage of the total annual storm count (b) for each category of intensity over 5-year periods from 1970 – 2004 (Source: Webster *et al.* 2005).

Despite the discrepancy in data analyses, most scientists concur that the recent increase in frequency and intensity of hurricanes in the Atlantic basin is consistent with increasing sea surface temperature trends and simulations that correlate escalations in GHG emissions with frequency intense tropical storms. However, there is also agreement that a longer data record is required to determine whether the frequency and intensity of hurricanes are following a natural oscillation or a temporal trend and if climate change is having a direct influence over these tendencies (Micheals, 2005; Pielke *et al.*, 2005; Webster *et al.*, 2005). A similar argument is made for studies of extreme temperature trends, such as Griffiths *et al.* (2005), as well as for the frequency and intensity of floods (Kundzewicz *et al.* 2005). In addition to understanding the past and current trends in climate change, it is important for decision making and design processes to simulate and project future climate and associated extremes. The AR4 of the IPCC (2007) made an assessment of and quantified projections of possible future climate extremes from a variety of global coupled atmosphere-ocean models with different forcings. The results are summarized in **Table 2**. The projected future impacts of climate change that will have a direct impact on engineering practices

include sea level rise, increasing precipitation, augmentation of both tropical and extra-tropical storm frequency and intensity, general drying of the mid-continental areas, reclining permafrost layer and melting of glaciers (IPCC, 2007).

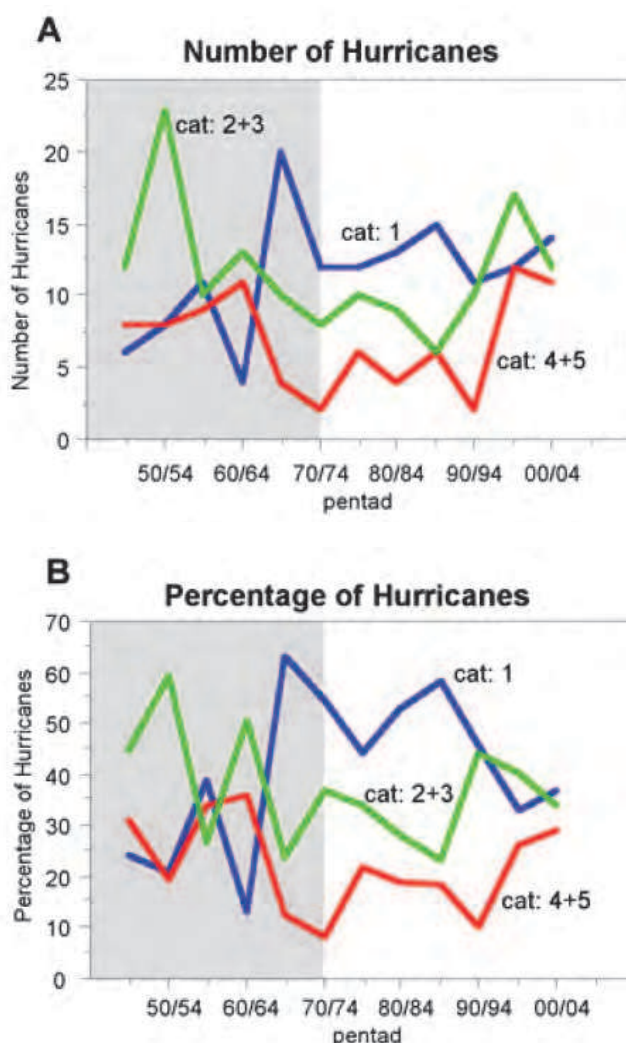


Fig. 6. Total number of storms (a) and percentage of the total annual storm count (b) for each category of intensity over 5-year periods from 1945 – 2004 (Micheals, 2005)

Although these forecasts are global in scale, different climatic and geographic regions around the world will be impacted in different ways and to varying degrees. In order to determine the level of risk associated with climate variability at a country level, researches are developing risk assessment techniques. For example, Brooks and Adger (2003), compiled fatality data from historical and recent climate related natural disasters to develop proxies indicating climatic risk. Using the CRED (2009) data, World Bank (2010) demonstrated that the number of people affected by climate related disasters are on the rise in lower-middle income countries due to rapid urbanization (**Figure 7**). Death toll from natural hazards and disasters has fallen but the number of the affected people has doubled every decade. Note that only climate cannot be blamed for such as increase, Factors like population growth, greater exposure of infrastructure to disasters and improvement in disaster reporting are also attributed to the increase in number of affected people (World Bank, 2010). Climate

change induced increased weather events together with these factors, number of affected people would increase.

Phenomenon and direction of trend	Likelihood that trend occurred in the late 20 <sup>th</sup> Century (typically after 1960)	Likelihood of a human contribution	Likelihood of future trends based on projections for 21 <sup>st</sup> Century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	<i>Very likely</i>	<i>Likely</i>	<i>Virtually certain</i>
Warmer and more frequent hot days and nights over most land areas	<i>Very likely</i>	<i>Likely (nights)</i>	<i>Virtually certain</i>
Warm spells/heat waves. Frequency increases over most land areas	<i>Very likely</i>	<i>More likely than not</i>	<i>Virtually certain</i>
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	<i>Very likely</i>	<i>More likely than not</i>	<i>Virtually certain</i>
Area affected by droughts increases	<i>Likely in many regions since 1970s</i>	<i>More likely than not</i>	<i>Likely</i>
Intense tropical cyclone activity increases	<i>Likely in some regions since 1970s</i>	<i>More likely than not</i>	<i>Likely</i>
Increased incidence of extreme high sea level (excludes tsunamis)	<i>Likely</i>	<i>More likely than not</i>	<i>Likely</i>

Note: Virtually certain > 99% probability of occurrence, Extremely likely >95%, Very likely > 90%, Likely > 66%, More likely than not > 50%, Unlikely< 33%, Very unlikely < 10%, extremely unlikely < 5%.

Table 2. Estimates of confidence in observed and projected changes in extreme weather and climate events (Adapted from IPCC, 2007)

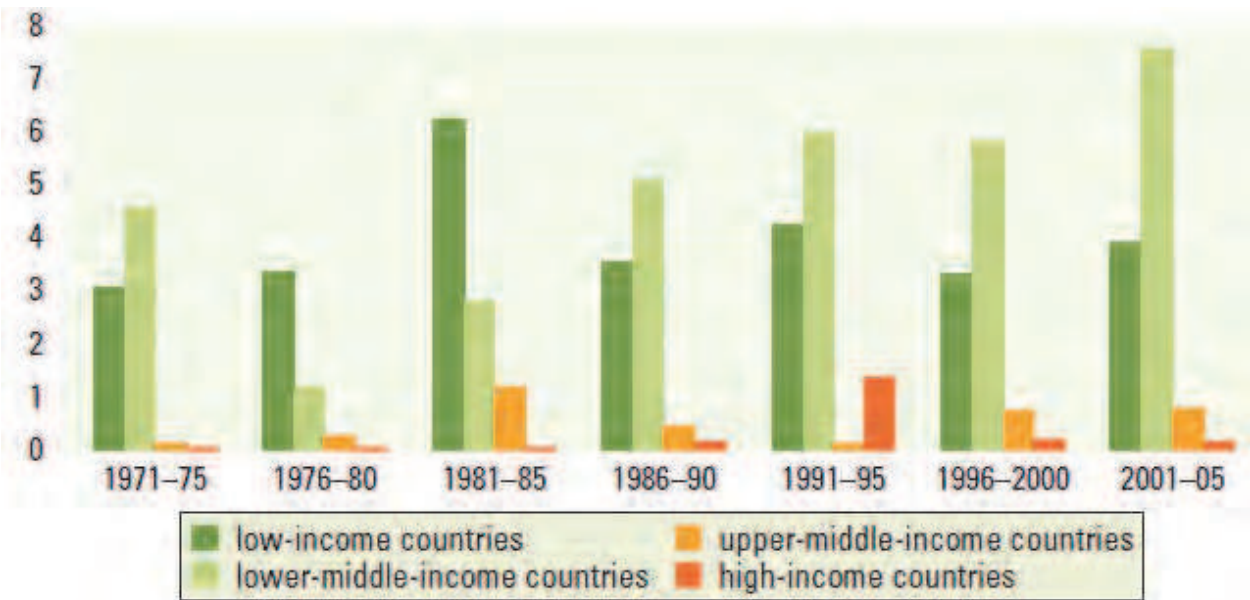


Fig. 7. People affected (as % share of population) by climate related disasters are increasing.  
Source: World Bank, 2010.

#### 4. Hazards, engineering infrastructures and disasters

Since the dawn of civilization, human constructed engineering structures to sustain civilization, save human lives and property. Remnants of ancient civilizations of Harappa and Mohenjodaro (Pakistan), Mesopotamia (Iraq) and Maya Civilizations (Mexico) carry footprints of ingenious engineering structures. The Mohenjodaro civilization extended from the Indus valley in Pakistan to the Yamuna along the bed of the river Ghaggar in Rajasthan, Gujarat and up to the mouths of the rivers Narmada and Tapi in India. The Mohenjodaro and the Maya civilizations of Mexico believed to have ruined by the floods, and droughts, respectively (Dasgupta and Chattopadhyay, 2004; Dahlin, 1983). Following are some modern day engineering infrastructures constructed to reduce vulnerability of natural hazards. These infrastructures have already provided enormous protection to communities and property. Note that future climate change has not been factored into the designs of these structures. On the other hand, failure of the New Orleans Flood Levees during the landfall of Hurricane Katrina in August 2005 caused a widespread disaster. Failure of a structure can happen due to a variety of reasons which include: under-design, lack of data for decision making, resource constraint that leads to design compromise, political decisions, bad workmanship, quality of materials used, etc. These infrastructures along with many other thousands need to be strengthened worldwide to manage additional risks to be posed by future climate change.

##### 4.1 Red river floodway, Winnipeg

The Red River Floodway (Figure 8), in conjunction with the Portage Diversion and Shellmouth Reservoir, has proven to be very effective in protecting City of Winnipeg from flooding (RRFORC, 2000). The then Provincial Government was severely criticized for borrowing money to build the Floodway in the 1960s. The return on this investment has been substantial in terms of minimizing the environmental and economic damage to



Winnipeg. Since the commissioning of the structure, the floodway has operated approximately 28 times, preventing approximately \$30 billion in flood damages. It was estimated that only in 2009, by diverting a peak water flow of approximately 1,218 m<sup>3</sup>/sec of water into the channel, CAD\$10 billion flood damage was averted (RRFEP, 2009). However, in 1997, the capacity of the flood way exceeded its design capacity. The floodway was not designed to provide benefits to residents of the valley south of Winnipeg (RRFORC, 2000). The International Joint Commission (IJC) (2000) made recommendations to upgrade the Floodway to accommodate a wide range of flow regimes, including those expected under future climate change. The Manitoba Floodway Authority has undertaken an expansion project of the floodway at an estimated cost of CAD\$ 665 million. The cost is being equally shared by the Federal Government and the Provincial Government of Manitoba. Once completed, the project would be able to protect people from a flood larger than the 1926 flood magnitude. The floodway expansion will substantially increase the drainage capacity of the current channel from 1,700 m<sup>3</sup>/sec to 4,000 m<sup>3</sup>/sec or an estimated magnitude of a 700-year flood event (RRFWA, 2011; RRFEP, 2009).



Fig. 8. The Winnipeg Floodway (Photo: Courtesy of Manitoba Floodway Authority, 2011 )

#### 4.2 The Thames barrier

The last time that central London flooded was in 1928 that killed 14 people. In 1953, a disastrous flooding occurred on the East Coast and the Thames Estuary when lives of over 300 people were lost. If this flood had reached central London's highly populated low lying areas the result could have been devastating. After the flood, a decision was taken to construct the Thames Barrier (**Figure 9**) and other ancillary flood defence improvements. Since its commissioning in October 1982, the Thames Barrier has been used to protect London from the risk of flooding (EA, 2006). However, tide levels are steadily increasing owing to a combination of factors. These include higher mean sea levels, greater storminess, increasing tide amplitude, the tilting of the British Isles (with the south eastern corner tipping downwards) and the settlement of London on its bed of clay. There is a plan underway to strengthen the barrier so that it can continue to provide protection against higher flooding risk due to the effects of climate change (see Section 5).





Source: Guardian.co.uk.

Fig. 9. The Thames barrier, UK

#### 4.3 Storm surge barrier, the Netherlands

The Dutch Government implemented the Delta Plan in the aftermath of a disaster flooding in 1953 that killed 1836 people in the lowlands of the Province of Zeeland (Gerritsen, 2005). This ambitious and costly plan shortened the Netherlands coastline by 700 kilometers. It closed off the sea by using a string of dikes and dams. However, the government decided to retain movement of tidal waters in the Eastern Scheldt through the storm surge barrier (**Figure 10**). Despite some environmental consequences caused by the project, the barrier has successfully provided protection from tidal flooding.



Source: [http://images.world66.com/st/or/m\\_/storm\\_surge\\_barrie\\_galleryfull](http://images.world66.com/st/or/m_/storm_surge_barrie_galleryfull)

Fig. 10. Storm Surge Barrier, the Netherlands

#### 4.4 New Orleans flood levees

A large part of City of New Orleans is below sea level. The City has been under the threat of flooding from the periodic high waters of the Mississippi River and waters of Lake Pontchartrain pushed by occasional severe hurricanes. Construction of the levees along the

River undertaken soon after the city was founded, and more extensive river levees were built as the city grew over the centuries. In the past, the levees protected the city from flooding in many occasions. However, when Hurricane Katrina landed, levees overtopped and breached in dozens of places and water inundated more than 75% of the City and killed more than 1,000 people. An American Society of Civil Engineers Commission found different failure mechanisms which include: scour erosion caused by overtopping, seepage, soil failure, and piping (ASCE, 2005).

## 5. Mainstreaming climate change: an engineering challenge

Since climate change is apparently already effecting development, future climate change impacts may need to be considered in engineering project planning, design, implementation and operation. The act of integrating both mitigation and adaptation measures into engineering projects to reduce and avoid damage from climate related risks is called mainstreaming. Mitigation refers to measures that reduce the propagation of climate change. The Kyoto Protocol is one such measure. On the other hand, Adaptation measures intend to reduce the impacts of and vulnerability to climate change that has either already occurred or is expected to take place in the future. The difference between mitigation and adaptation is illustrated in **Figure 11**. The different levels of adaptation are outlined in **Figure 12**.

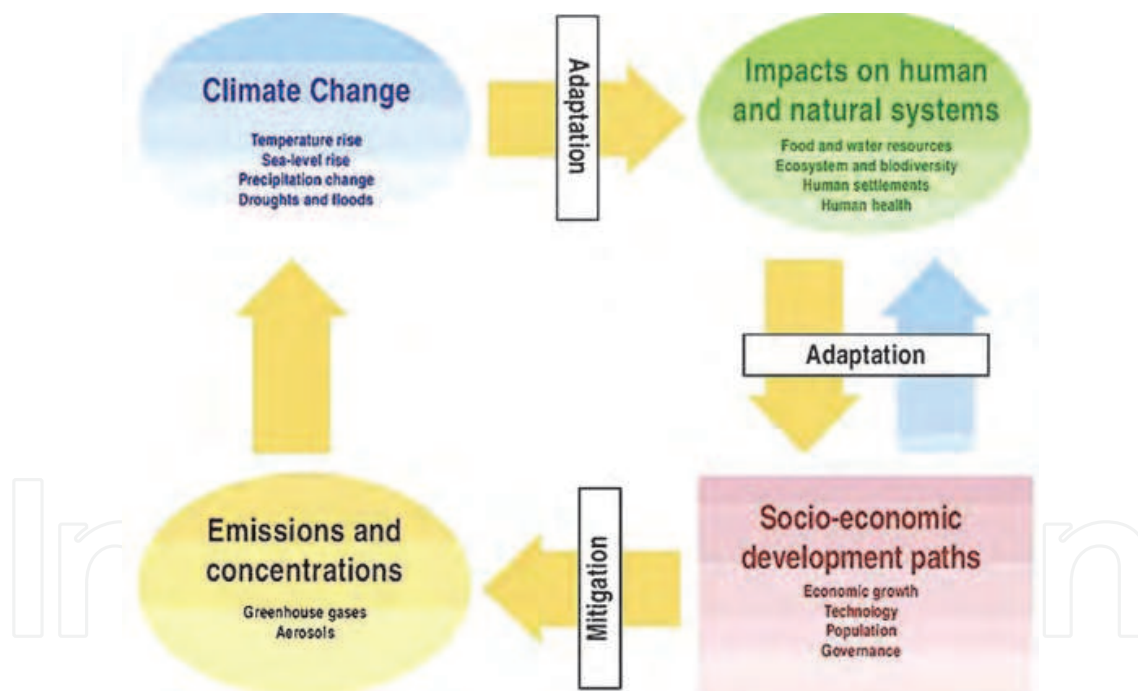


Fig. 11. Schematic depicting the concepts of mitigation and adaptation (Source: IPCC, 2001b)

Mainstreaming is accomplished by incorporating climate risks and weather extremes into short term decision making as well as long term visions. In addition, current engineering practices should be modified since they often take into account historical climate, which may not be suitable for predicted future climate and extremes. On the other hand, mainstreaming climate change into engineering projects is only possible when adequate levels of capacity and development exists. Therefore, mainstreaming climate change involves a dynamic cycle of mitigation, adaptation and development that aims to enhance

the efficiency and sustainability of climate change initiatives (ADB, 2005; Agrawala, 2005; Swart *et al.*, 2003).

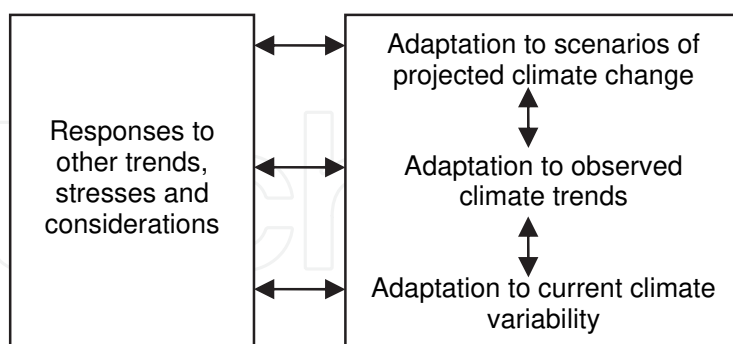


Fig. 12. Levels of Adaptation (Source: Agrawala, 2005)

However, mainstreaming climate change into development objectives is made difficult due to barriers such as short term funding and competing/conflicting agendas within governments and donor agencies. In order to reduce or eliminate these hurdles, private and public institutions must promote programs that increase awareness in climate change issues, improve access to credible, accurate and relevant information and expand resources to implement response measures. This mainstreaming-friendly environment will help enable the implementation of specific climate proofing activities within the broader sustainable development context (ADB, 2005; Agrawala, 2005).

Since issues such as poverty, water scarcity, food availability and security are prevailing issues for the general population and climate change mitigation and adaptation require a certain level of capacity to be implemented, short-term economic benefits are usually prioritized over long term climate change goals. However, short term development goals may provoke maladaptation (Agrawala, 2005). For example, hydropower projects, which are anticipated to increase electricity production and thus improve development, may increase the risk of flooding if future river flows exceed the design parameters of the dam. Therefore, climate oriented risk screening, project selection and decision making tools that can be integrated into environmental impact assessments, disaster response strategies, land use planning and urban design should be developed. The benefits from these tools can be augmented through the creation of national, regional and global linkages that facilitate sharing and cooperation.

The Asian Development Bank, under its Climate Change Adaptation Program for the Pacific, has developed a set of guidelines that are to be followed as part of the developmental process. They include (ADB, 2005):

- Managing climate risks as a part of sustainable development projects
- Ensuring intergenerational equity
- Adopting an integrated long-term approach to adaptation
- Taking full advantage of partnerships
- Exploiting the full potential of sustainable technologies
- Strengthening and utilizing national capacity
- Improving the credibility and application of information

- Improving regulations
- Climate proofing legislation
- Reinforcing climate change institutions
- Adapting economics in favor of climate proofing
- Increasing access to financial support
- Carry out risk assessments
- Complement other development goals with climate change adaptation
- Provide for continual improvements

### 5.1 Examples of mainstreaming

The mainstreaming of climate change mitigation measures into engineering projects is a common practice that has been going on before the introduction of the Kyoto protocol in 1997. Mitigation measures include energy efficient equipment and systems, renewable energy, air pollution control techniques, afforestation, etc. (Agrawala, 2005). Although the development and implementation of climate change adaptation measures is a recent phenomenon, initiatives have been taken to develop infrastructure and legislation that reduces or eliminates the risk of climate related events such as floods and droughts. This includes dykes, evacuation strategies, public awareness campaigns, insurance schemes, sustainable land use plans, rain water harvesting techniques, crop diversification, etc. It is well recognized that both mitigation and adaptation measures must not only include physical projects but “soft” techniques as well (Kabat and Vellinga, 2005).

A study by the Organization for Economic Co-operation and Development (Agrawala, 2005) explored the extent of climate change mainstreaming activities around the world. For example, Nepal is at risk from flooding due to accelerating glacial melt and increasing glacial lake levels. The resulting increase in river flows has been recognized as a potential benefit with regards to hydropower generation but also as a possible detriment to settlements and infrastructure. As such, Nepal has come up with a number of adaptation strategies that promote the benefits while inhibiting the risks. They include building more micro-scale hydro power facilities in low risk areas, developing early warning systems, and incorporating stream flow variability into project designs. Another example surrounds the Nile River in Egypt. Egypt depends on the Nile for both irrigation and navigation. In recent decades the river level has fluctuated significantly, putting stress on the duality of the river’s role. In order to adapt to future declines in the river water level, Egypt is modifying the navigable channel in order to preserve water depth for navigation without sacrificing irrigation capacity. This physical adaptation is complemented with water use regulations and improved irrigation and crop water efficiency. A governmental department was also created to monitor, manage and forecast the Nile water levels.

Another study was made by the Asian Development Bank (ADB, 2005) to document various case studies of climate change adaptation in the Pacific Islands. The intent of the case studies was to provide successful examples for other communities, regions and nations to follow. For instance, Micronesia is at risk from cyclones, typhoons, sea level rise, extreme precipitation, land slides and El Nino influenced droughts. In order to adapt to these potentially detrimental events, numerous small, climate proof infrastructure projects are being implemented. They included new road networks that are a minimum elevation above sea level and incorporate drainage technologies, revitalization of breakwater facilities based on projected increases in design requirements for wave heights, revamping building codes



to require minimum floor elevations and relocation buildings that are in high hazard zones. These physical measures were accompanied by a total climate proofing of the Micronesia National Strategic Development Plan.

Other case studies that focus on mainstreaming climate change adaptation into national strategies include:

- The formulation of flood preparedness programs into Bangladesh's National Disaster Management Plan (Mallick *et al.*, 2005).
- The development of institutional mechanisms for the distribution of local, drought adaptable seed varieties in Kenya (Orindi and Ochieng, 2005).
- The initiation of the \$118 US Climate Changes Spatial Planning Research program and the Adaptation Program for Spatial Planning and Climate in the Netherlands which will investigate "softer" strategies for climate proofing floodplains, the agricultural industry and water resources in the Netherlands (Kabat and Vellinga, 2005).
- The establishment of the Thames Estuary 2100 (TE2100) project, which has devised a Risk Management Plan (RMP) for testing the suitability of flood risk management options. It is comprised of different elements: *First*, it presents the strategic direction for managing flood risk in discrete policy areas across the Thames estuary; and *second*, it contains recommendations on what actions the U.K. Environment Agency and others will need to take in the short- (next 25 years), medium (the following 40 years) and long term (to the end of the century). The RMP is based upon current guidance on climate change, but it is adaptable to changes in future projections for sea level rise and climate change over the current century. Public consultations on the project held from April to June, 2011 (EA, 2011).

Furthermore, global insurance companies are presently looking for ways of mainstreaming climate change into their general strategies. Although the traditional approaches for managing exposure to natural hazards have been to limit risks, control damages, transfer risks or adjust product prices, companies are now shifting to a more holistic approach. This includes developing new insurance markets, setting insurance prices that reflect the degree of hazard for specific locations, providing guidance on emergency response and recovery processes and working with governments to promote community risk management (CII, 2005).

## 6. Concluding remarks

- Frequency of some extreme weather events are increasing and their severity is also on the rise. However, there are regional differences.
- Economic losses from extreme weather events non-linearly increasing due mainly to rapid rise in development activities in high risk areas (e.g., flood plains, coasts, deltas, etc.).
- Extreme weather events pose unique threats to engineering infrastructures. They have been saving human lives and property but their failures also facilitate disasters.
- Climate change can increase frequency and severity of extreme weather events that would put engineering infrastructures at additional risks.
- Mainstreaming of climate change risk into engineering plans, designs, maintenance and monitoring activities will reduce future vulnerability.
- To facilitate mainstreaming, there is a need of dialogue between climate researchers, engineering community, policy making authorities and other stakeholders.



## 7. References

- American Society of Civil Engineers (ASCE), 2005. ASCE Member Share Findings on Katrina with US Senate Committee, Calls for National Levee Inspection and Safety Program. *ASCE News*, December 2005, Vol. 30, Number 12, p.1.
- Asian Development Bank (ADB), 2011. ADB-World Bank Assess Pakistan Flood Damage at \$9.7 Billion (<http://adb.org/Media/Articles/2010/13363-pakistan-flooding-assessments/>) (accessed in 2011).
- Asian Development Bank (ADB), 2005. Climate Proofing – A risk based approach to adaptation. Philippines. pp. 191.
- Agrawala, S. [ed.], 2005. Bridge Over Troubled Waters – Linking Climate Change and Development. Organization for Economic Co-operation and Development, Paris. pp. 153.
- Alexander, L.V., X. Zhang, T.C. Peterson, J. Caesar, B. Gleason, A. Klein Tank, M. Haylock, D. Collins, B. Trewin, F. Rahimzadeh, A. Tagipour, P. Ambenje, K. Rupa Kumar, J. Revadekar, G. Griffiths, L. Vincent, D.B. Stephenson, J. Burn, E. Aguilar, M. Brunet, M. Taylor, M. New, P. Zhai, M. Rusticucci, J.L. Vazquez-Aguirre, 2006. Global observed changes in daily climate extremes of temperature and precipitation, *Journal of Geophysical Research*, 111, doi:10.1029/2005JD006290, 2006.
- Brooks, N., and W. N. Adger, 2003. Country level risk measures of climate-related natural disasters and implications for adaptation to climate change: Tyndall Working Paper 26. Tyndall Center, U.K.
- Congressional Budget Office (CBO), 2002. Federal Reinsurance for Disasters: Chapter 2- The Insurance Market's Response to Disasters (<http://www.cbo.gov/doc.cfm?index=3787&type=0&sequence=3>).
- Changnon, S.A., Changnon, D., Fosse, E.R., Hoganson, D.C., Roth Sr., R.J. and Totsch, J.M., 1997. Effects of Recent Weather Extremes on the Insurance Industry: Major Implications for the Atmospheric Sciences. *Bulletin of the American Meteorological Society*, 78(3), 425-435.
- Chan, J.C.L. and Liu, S.L., 2004. Global warming and western North Pacific typhoon activity from an observational perspective. *Journal Climate*, 17, 4590-4602.
- The Chartered Insurance Institute (CII), 2005. Research Report: Climate change and insurance. London, 2001.
- Dahlin, B.H., 1983. Climate and Prehistory on the Yucatan Peninsula. *Climatic Change*, 5(3), 245-263.
- Dasgupta, T. and Chattopadhyay, R. N., 2004. Ecological Contradictions through Ages: Growth and Decay of the Indus and Nile Valley Civilizations. *Journal of Human Ecology*, 16(3), 197-201.
- Delworth, T.L. and M.H. Mann, 2000: Observed and simulated multidecadal variability in the Northern Hemisphere. *Clim. Dyn.*, 16, 661-676.
- Emanuel, K., 2005. Increasing destructiveness of tropical cyclones over the past 30 years. *Nature*, posted on-line August 4, 2005.
- Environment Agency, 2011. Thames Estuary 2100 (<http://www.environment-agency.gov.uk/homeandleisure/floods/104695.aspx>) (accessed in 2011).

- Environment Agency, 2006. The Thames Barrier - a description of flooding risks in London (<http://www.environmentagency.gov.uk>).
- Folland, C.K., D.E. Parker and T.N. Palmer, 1986: Sahel rainfall and worldwide sea temperatures 1901-85. *Nature*, 320: 602-607.
- Frich, P., L.V. Alexander, P. Della-Marta, B. Gleason, M. Haylock, A. Klein-Tank and T. Peterson, 2001: Observed coherent changes in climatic extremes during the second half of the 20th Century. *Climate Research* 19: 193-212.
- Gerritsen, H., 2005. What Happened in 1953? The Big Flood in the Netherlands in Retrospect. *Philosophical Transactions: Mathematical, Physical and Engineering Sciences*, 363 (1831), 1271 - 1291.
- Griffiths, G. M., et al., 2005. Change in mean temperature as a predictor of extreme temperature change in the Asia-Pacific region. *Int. J. Climatol.* 25: 1301-1330.
- International Joint Commission (IJC), *The Next Flood: Getting Prepared*. IJC, Ottawa.
- Intergovernmental Panel on Climate Change (IPCC), 2007. Climate change 2007 - the scientific basis. Summary for policymakers, a report of Working Group I. Intergovernmental Panel on Climate Change, Geneva.
- Intergovernmental Panel on Climate Change (IPCC), 2001a. *Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [Watson, R.T. and the Core Writing Team (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 398 pp.
- Intergovernmental Panel on Climate Change (IPCC), 2001b. Climate change 2001 - Impacts, Adaptation and Vulnerability, a report of Working Group II. Intergovernmental Panel on Climate Change, Geneva.
- Kabat, P and P. Vellinga, 2005. Climate Proofing the Netherlands. *Nature*, 438, 283-284.
- Kundzewicz, Z. W., U. Ulbrich, T. Brucher, D. Graczyk, A. Kruger, G. C. Leckebusch, L. Menzel, I. Pinskiwar, M. Radziejewski and M. Szwed, 2005. Summer Floods in Central Europe - Climate Change Track? *Natural Hazards* 36: 165-189
- Lal, M, 2001: Tropical Cyclones in a Warmer World, *Current Science*, 80(9), 1103-1104.
- Landsea, C.W., Peilke Jr., R.A., Mestas-Nunez, A.M. and Knaff, J.A., 1999. Atlantic basin Hurricanes: Indices of Climatic Changes. *Climatic Change*, 42, 89-129.
- Mallick, D.L., A. Rahman, M. Alam, A. S. Juel, A. N. Ahmad and S. S. Alam, 2005. Floods in Bangladesh: A shift from disaster management towards disaster preparedness. *IDS Bulletin*, 36(4), 53-70.
- Meehl GA, Karl T, Easterling DR, Changnon S, Pielke Jr R, Changnon D, Evans J, Groisman PY, Knutson TR, Kunkel KE, Mearns LO, Parmesan C, Pulwarty R, Root T, Sylves RT, Whetton P, Zwiers F. 2000. An introduction to trends in extreme weather and climate events: observations, socio-economic impacts, terrestrial ecological impacts, and model projections. *Bulletin of the American Meteorological Society* 81(3): 413-416.
- Micheals, P., 2005. Global Warming and Hurricanes: Still No Connection. Review, 16 Sep 2005. [www.tcsdaily.com/article.aspx?id=091605F](http://www.tcsdaily.com/article.aspx?id=091605F).
- Mirza, M.M.Q., Warrick, R.A., Ericksen, N.J. and Kenny, G.J., 2001. Are Floods Getting Worse in the Ganges, Brahmaputra and Meghna Basins? *Environmental Hazards*, 3, 37-48.

- Mirza, M. and Koshida, G., 2005. Reducing vulnerability to climate change: need for an adaptation baseline. Paper Presented in the 6<sup>th</sup> IHDP Open Forum Meeting, Bonn, Germany, 9-14 October.
- Munich Re, 2010. Topics Geo 2010. Munich Re, Germany.
- Munich Re, 2004. Topics Geo 2004. Munich Re, Germany.
- NASA, 2010. 2009: Second Warmest Year on Record; End of Warmest Decade (<http://www.nasa.gov/topics/earth/features/temp-analysis-2009.html>).
- Orindi, A., and A. Ochieng, 2005. Seed Fairs as a Drought Recovery Strategy in Kenya. *IDS Bulletin*, 36(4), 71-86.
- Pielke Jr., R. A., C. Landsea, M. Mayfield, J. Laver and R. Pasch, 2005. Hurricanes and Global Warming. *Bulletin of the American Meteorological Society*, in press.
- Pielke Jr, R.A., and R.A. Pielke, Sr., 1997. Hurricanes: Their nature and impacts on society. John Wiley and Sons, England, 279.
- Pielke, R.A., 1990. The hurricane. Routledge Press, London, England, 228
- Red River Floodway Operation Review Committee (RRFORC), 2000. *A Review of the Red River Floodway Operating Rules*, Winnipeg.
- Manitoba Floodway Authority (MFA), 2011. What is Floodway Expansion? (<http://www.floodwayauthority.mb.ca/floodfacts.html>. Accessed June 25, 2011).
- Red River Floodway Expansion Project (RRFEP), 2009. *More Protection. More Opportunities*. September 2009 ([http://www.floodwayauthority.mb.ca/pdf/newsletter\\_sept\\_2009.pdf](http://www.floodwayauthority.mb.ca/pdf/newsletter_sept_2009.pdf)).
- Saunders, M.A. and Lea, A.S., 2008. Large contribution of sea surface warming to recent increase in Atlantic hurricane activity. *Nature*, vol.451, 557-560.
- Singh, OP, Ali Khan, TM and Rahman, S., 2000. Changes in the frequency of tropical cyclones over the North Indian Ocean, *Meteorology and Atmospheric Physics* 75 (1-2), 11-20.
- Swart, R., Robinson, J. and Cohen, S., 2003. Climate Change and Sustainable Development: Expanding the Options. *Climate Policy*, 3(s1), S19-40.
- Torjman, S., 1998. The Key to Kyoto: Social Dimensions of Climate Change. Caledon Institute of Social Policy, Ottawa.
- Webster, P.J., G. J. Holland, J. A. Curry and H.R. Chang, 2005. Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science*, 309: 1844-1846.
- Wigley, TML. 1985. Impact of extreme events. *Nature* 316: 106-107.
- Wigley, TML. 1988. The effect of changing climate on the frequency of absolute extreme events. *Climate Monitor* 17: 44-55.
- World Bank, 2010. World Development Report 2010: Development and Climate Change. World Bank, Washington, D.C.



## **Climate Change - Research and Technology for Adaptation and Mitigation**

Edited by Dr Juan Blanco

ISBN 978-953-307-621-8

Hard cover, 488 pages

**Publisher** InTech

**Published online** 06, September, 2011

**Published in print edition** September, 2011

This book provides an interdisciplinary view of how to prepare the ecological and socio-economic systems to the reality of climate change. Scientifically sound tools are needed to predict its effects on regional, rather than global, scales, as it is the level at which socio-economic plans are designed and natural ecosystem reacts. The first section of this book describes a series of methods and models to downscale the global predictions of climate change, estimate its effects on biophysical systems and monitor the changes as they occur. To reduce the magnitude of these changes, new ways of economic activity must be implemented. The second section of this book explores different options to reduce greenhouse emissions from activities such as forestry, industry and urban development. However, it is becoming increasingly clear that climate change can be minimized, but not avoided, and therefore the socio-economic systems around the world will have to adapt to the new conditions to reduce the adverse impacts to the minimum. The last section of this book explores some options for adaptation.

### **How to reference**

In order to correctly reference this scholarly work, feel free to copy and paste the following:

M. Monirul Qader Mirza (2011). Mainstreaming Climate Change for Extreme Weather Events & Management of Disasters: An Engineering Challenge, Climate Change - Research and Technology for Adaptation and Mitigation, Dr Juan Blanco (Ed.), ISBN: 978-953-307-621-8, InTech, Available from:  
<http://www.intechopen.com/books/climate-change-research-and-technology-for-adaptation-and-mitigation/mainstreaming-climate-change-for-extreme-weather-events-management-of-disasters-an-engineering-chall>

**INTeCH**  
open science | open minds

### **InTech Europe**

University Campus STeP Ri  
Slavka Krautzeka 83/A  
51000 Rijeka, Croatia  
Phone: +385 (51) 770 447  
Fax: +385 (51) 686 166  
[www.intechopen.com](http://www.intechopen.com)

### **InTech China**

Unit 405, Office Block, Hotel Equatorial Shanghai  
No.65, Yan An Road (West), Shanghai, 200040, China  
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元  
Phone: +86-21-62489820  
Fax: +86-21-62489821

© 2011 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the [Creative Commons Attribution-NonCommercial-ShareAlike-3.0 License](https://creativecommons.org/licenses/by-nc-sa/3.0/), which permits use, distribution and reproduction for non-commercial purposes, provided the original is properly cited and derivative works building on this content are distributed under the same license.

IntechOpen

IntechOpen