Understanding Climate Change in South Asia

From an Effort to Turn Local Tsunami Recovery into Regional Disaster Risk Reduction for the Poor

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In this issue

KEY IDEA

Understanding Climate Change in South Asia

Recently, I had an opportunity of discussing implications of climate change in South Asia with some of the young and upcoming journalists from South Asia in Colombo, Sri Lanka, March 20 and 21, 2007, at the Sri Lanka Press Institute. This two-day workshop was organised by The World Conservation Union (IUCN) of Sri Lanka and the Commonwealth Foundation, UK. In conclusion we emphasised the need for evolving bottom up public dialogue in favour of the poor affected or vulnerable to climate change risk in South Asia, including two key areas for the media (and donors) to directly address: (a) developing better policy and public understanding of the grassroots interplay of climate change, poverty, and economic growth; and (b) mapping who is doing what as well as how it works on the ground. This event was inspiring in its openness and honesty especially with regard to enlisting areas of ignorance; this led AIDMI to prepare this issue of *southasiadisasters.net* on climate change, its science, impact and coping options for South Asian communities.

Extreme events such as floods, droughts, and tropical cyclones have increased in Asia. In South Asia "repeat-droughts" or "repeat-floods" are becoming common in two out of ten communities, journalists agreed. There are key documents available that provide a top-down scientific and predictive macro view of South Asian climate change. We as a group realised in the Sri Lanka event that it is important to construct a local perspective for the humanitarian sector of Asia regarding rapidly expanding climate risk. The journalists reported that in each country in South Asia such local perspective was lacking. Floods due to disaster risk and flood due to climate risk can not be distinguished by the responding humanitarian worker on the Brahmaputra riverbed in India or Bangladesh. It has been estimated that there is loss of landmass in coastal areas, repeated droughts, and chronic flooding leading to permanent, semi-permanent, and iterative displacement of individuals, families, communities and occupational groups. This, in turn, leads to economic and political costs, causing 15% to upto 30% migration in South Asia settlements by 2015. At the local level all risks converge, natural and climatic, causing a loss of basic human security across South Asia.

From fieldwork and other sources, including recent evaluations in the region of the UN system and the international financial institutions by AIDMI, we discussed with the unrelenting journalists how climate change may reduce poor people's livelihood assets, alter regional food security, increase heat related human and animal mortality, and may increase prevalence of vector borne diseases such as malaria. For each situation the journalists had a location and an event to recount. The Millennium Development Goal of a Global Partnership may be delayed due to unequal impact of climate change risk on Northern and Southern partners working in South Asia. More research and policy work, in addition to process documentation and local action research, is needed to better understand climate change risk impact and adaptation at the grassroots; more and comprehensively informed media reporting (and suitable sensitive funding by donors and national governments) is an effective beginning. Adaptive capacity varies between countries in the region making any risk management effort difficult across geographic areas such as the

Brahmaputra plains or Indo–Pak–Afaghan desert, or Indo–Nepal mountain range where many countries have overlapping risks, as well as across sectors such as early warning of floods, droughts, and cyclones; or sea level rise and institutional interests in investments, information, and local initiatives. In the end we concluded that it is important to enlist and analyse the implications of climate change such as mean climate variability, extreme events, and sea level risk for poverty eradication. Season, location, and community specific research is needed. Donors and governments have a pressing need to take a leap ahead to find more effective ways of resourcing ideas, action, and advocacy development around climate change risk in South Asia.

We did not argue on some aspects, to start with, the key aspects of South Asian reality: the concentration and persistence of poverty, key implications of climate change in South Asian countries, dependence of countries on natural resources, rapid economic growth, and limited and skewed country capacity to invest in climate risk mapping and managing. Once the agreement was achieved, examples after examples poured in from the journalists to show the delay, deformation, and destruction of development due to climate change, pushing the poor back to poverty and keeping them there, and the economic and ecological problems that almost always define any development or risk management initiative in South Asia. The reality that was presented there was selective. The selection was in favour of the bottom up community perspective gained by the journalists. But that is no reason to believe that the representation of the reality is unacceptable or inaccurate. After all we read and watch journalists and journals to learn how our day-to-day life is changing. ■

Mihir R. Bhatt

Potential Impacts of Climate on the Millennium Development Goals

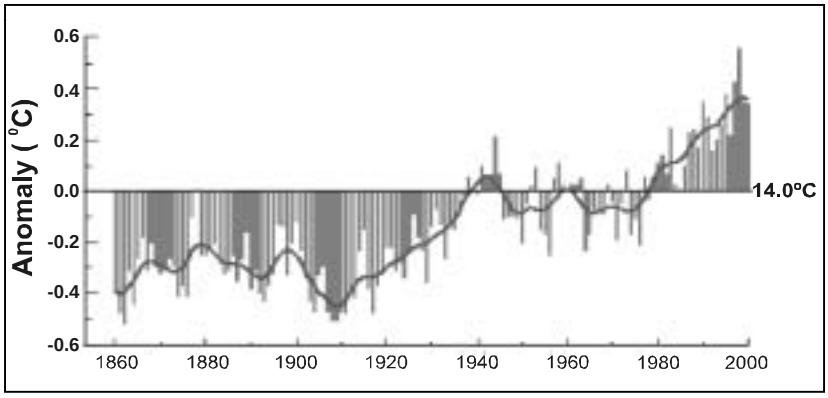
Climate change-induced losses may pose a serious threat in meeting the Millennium Development Goals (MDGs). The losses are likely to affect the poor more, worsening opportunities to move out of poverty. These risks should be assessed and climate change adaptation options should be linked to development processes right from the beginning. The table below prepared by World Bank notes how climate change and associated losses may affect the achievement of the MDGs.

Millennium Development Goals: Climate Change as across cutting issues

Millennium Development Goal	Examples of links with climate change
Eradicate extreme poverty and hunger (Goal 1)	Direct Impacts: • Climate change may reduce poor people's livelihood assets. • Climate change may alter the path and rate of economic growth due to changes in natural systems and resources, infrastructure and labour productivity. A reduction in economic growth directly impacts poverty through reduced income opportunities. • Climate change may worsen regional food security.
Health related goals: Combat major diseases Reduce infant mortality Improve maternal health (Goals 4,5, and 6)	Direct Impacts: • Direct effects of climate change may include increases in heat-related mortality and illness associated with heat waves (which may be balanced by less winter cold related deaths in some regions). • Climate change may increase the prevalence of some vector-borne disease (e.g. malaria and dengue fever), and vulnerability to water, food or person-to-person borne diseases (e.g. cholera and dysentery). • Children and pregnant women are particularly susceptible to vector and water borne diseases.
Achieve universal primary education (Goal 2)	Indirect Impacts: • Links to climate change are less direct but loss of livelihood assets (natural, health, financial and physical capital) may reduce opportunities for full time education in numerous ways. Natural disasters and drought reduce children's available time (which may be diverted to household tasks) while displacement and migration can reduce access to education opportunities.
Promote gender quality and empower women (Goal 3)	Indirect Impacts: • Climate change may exacerbate current gender inequalities. Depletion of natural resource and decreasing agricultural productivity may place additional burdens on women's health, and reduce time available to participate in decision making processes and income generation activities. • Climate related disasters have been found to impact more severely female-headed households particularly where they have fewer assets to start with.
Ensure environmental sustainability (Goal 7)	Direct Impact: • Climate change may alter the quality and productivity of natural resources and eco-systems, some of which may be irreversibly damaged, and these changes may also decrease biological diversity and compound environmental degradation.
Global partnerships (Goal 8)	Direct Impact: • Global climate change is a global issue and responses require global cooperation, especially to help developing countries adapt to the adverse impact of climate change.

Climate Change: Past, Present and Future

Global warming associated with anthropogenic production of greenhouse gases has been a hotly discussed topic for decades. Analysis of observations of surface temperature shows that there has been a global mean warming of about 0.7ºC over the past one hundred years. For any change in mean climate, however, there is likely to be an amplified change in extremes. The extremes may exceed tolerances of both natural and human systems—for example, floods that used to have an expected return period of 100 years may recur in 50 or 30 years—and therefore, are exceedingly important. However, some argue that the data do not show a measurable upward trend in global temperatures. Some think that any increase in global temperatures we are seeing could be a natural climate shift, or it could be due to factors other than greenhouse gases. Whatever may be the debate, our earth has come across periods of global cooling and warming, known to geology as glacial and interglacial periods.



Change in global annual mean temperature from 1860–2000 (http://www.cgd.ucar.edu/cas/GLOB_CHANGE/trenberth.html).

A Brief Overview of Climate Change through Geological Time

The first recorded massive freezing occurred on the earth some 2.2 billion years ago, followed by a billion years or so of warmth. The cooling that took place between 850 to 630 million years ago was even more massive; the global temperature plunged by as much as 45ºC. The entire surface of the planet may have frozen solid, with ocean ice up to 800 meters thick at higher latitudes and tens of meters thick in the tropics, permanent sea ice extending to or very near the equator. The condition is popularly known as Snowball Earth. Volcanic eruptions that pumped out lots of heat and gases are expected to have thawed the ice, reformed the atmosphere, and rescued our earth from the snowball condition. Interestingly the end of this hyper-frigid episode marked by the Cambrian outburst, the springtime event of life's history. As the earth warmed, it probably had the wildest weather it has ever experienced, with hurricanes powerful enough to raise waves to the heights of skyscrapers and rainfalls of indescribable intensity. Minor ice ages occurred from 460 to 430 million years ago and at intervals from 350 to 260 million years ago *(Bryson, 2003)*. The last glacial period ended about 10,000 years ago.

Causes of Climate Change

Milankovitch Cycles: Sun-Earth Geometry

Fluctuations in the intensity of solar radiation the earth receives are considered the most likely cause of glacial / interglacial cycles. A Serbian Engineer, Milutin Milankovitch, in 1938, described how the intensity of the incoming solar radiation varies over time. He identified three parameters that change the angle of orientation and distance of the earth relative to the sun: eccentricity of the earth's orbit, tilt of the earth's axis and precession of equinoxes.

Eccentricity

Eccentricity measures how much an ellipse is departing from circularity. On a periodicity of nearly 100,000 years, the eccentricity of the earth's orbit fluctuates from 0.005 (nearly circular) to 0.058 (mildly elliptical), changing the distance between the earth and the sun as the former revolves around the latter. If the earth's orbit were circular, there would be no variation in the earth-sun distance and no seasonal variations in weather. The present eccentricity is 0.017, which causes 6% increase in incoming solar radiation in July compared to that in January. The same difference when the eccentricity of the earth's orbit is at its maximum (0.058) will be 23%.

Axial Tilt

The inclination of the earth's axis against the plane of the earth's orbit changes from 21.5 to 24.5 degrees on a cycle of about 41,000 years. With less tilt, there is less variation in incoming solar radiation during summer and winter; however, the solar radiation is less evenly distributed around the equator and the poles. The earth's axis is presently inclined at 23.5 degrees to the plane of its orbit.

Precession

Precession of the equinoxes is the change in the direction of the earth's axis of rotation relative to the Sun at the time of perihelion[1] and aphelion[2]. The earth takes approximately 23,000 years to complete a cycle of precession.

Movement of Tectonic Plates

Earth's internal heat causes tectonic plates to move relative to each other. The Indian Plate, for example, drifted northwards at a speed of 16 cm / year and covered a distance of 6000 km before colliding with the Eurasian Plate some 65 million years ago. The collision gave birth to the Himalaya– the biggest mountain range on the planet today—and closed the Tethys Sea that existed between India and Tibet. The collision is ongoing—with a reduced speed of five cm / year though—and the Himalaya is still growing. The rise of the Himalaya had a significant influence on climate. It brought monsoon to the region, for instance. The higher landmass of the Himalaya was itself cooler and additionally it diverted winds in a way that made them flow north and towards North America, making it more susceptible to long-term chills. Augmenting the situation, Panama rose from the sea, closing the gap between North and South America, disrupting the flows of warming currents between the Pacific and the Atlantic, and changing patterns of precipitation across at least half of the world. One other consequence was a drying out of Africa.

The above paragraph illustrates that the movement and positioning of the tectonic plates have a major role to play in determining the earth's climate. Geological evidence indicates that ice sheets are formed when continents are so positioned that they block the current of warm water from the equator to the poles. Furthermore, had North America, Eurasia and Greenland been just 500 km north from where they are now, we would have permanent and inescapable ice ages *(Bryson, 2003)*.

The complexity of the interference among the factors that can bring about climate change makes it extremely difficult to predict whether we are heading towards a cooler or a warmer climate in longer run.

Volcanism

Volcanic eruption of biblical magnitude like the one that happened with the Deccan Traps in India about 65 million years ago can have a tremendous impact on the earth's climate. The Deccan Traps covered an area of 500,000 sq km and are suspected to be a cause of dinosaur's demise. The last super-volcano that occurred in northern Sumatra 74,000 years ago brought at least six years of 'volcanic winter' followed by numerous poor growing seasons. The event is thought to have carried human beings to the brink of extinction, reducing the global population to no more than a few thousand individuals. Some evidence suggests that for the next twenty thousand years the total number of people on the earth was never more than a few thousand at any time. The famous Yellowstone National Park of the United States is a volcanic caldera, 65 km across and 9500 sq km in area. The park sits on an enormous hot spot, a reservoir of molten rock that begins at least 200 km down in the earth and rises near the surface. The heat from the hot spot powers all of Yellowstone's vents, geysers, hot springs and popping mud pots. The pressure that the magma chamber below exerts on the crust above has lifted Yellowstone and its surrounding territory about half a kilometre higher than they would otherwise be. The Yellowstone eruption of two million years ago put out enough ash to bury New York State to a depth of 20 m. The ash fall from the last Yellowstone eruption covered all or parts of nineteen western states of the USA and parts of Canada and Mexico. Yellowstone is still an active volcano, averaging one massive blow every 600,000 years. The last one was 630,000 years ago *(Bryson, 2003)*!

Big volcanic eruptions, to summarise, have strength sufficient to modify the climate in a significant way. To begin with, various gases released through such eruptions are believed to have played a major role in constructing the earth's atmosphere. Volcanic eruptions may have both cooling and warming effects, but the latter is considered more prominent. Aerosols (a collection of airborne solid or liquid particles, with a typical size between 0.001 and 10 mm that reside in the atmosphere for at least several hours *(IPCC, 2001a)*) emitted from volcanoes may block and scatter the sunlight coming towards the earth's surface and contribute towards cooling. In contrast, volcanoes can raise temperatures by increasing carbon dioxide and other greenhouse gases concentration in the atmosphere.

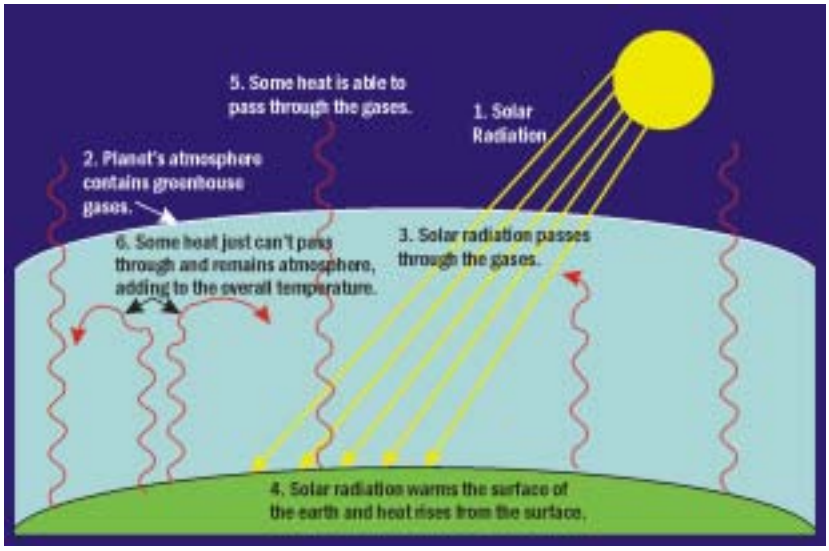
Concluding remarks

Longer-term variation in climate is thus a complex manifestation of the interaction of several driving factors. The factors external to the earth system include variation in the sun's energy output and changes in the earth-sun distance and orientation of the earth in relation to the sun, and those internal include the movement of tectonic plates and volcanic activities. The next article will explore how the variation in the concentration of greenhouse gases in atmosphere, a hot topic in recent times, can contribute towards climate change. The complexity of the interference among the factors that can bring about climate change makes it extremely difficult to predict whether we are heading towards a cooler or a warmer climate in longer run. ■

1 The point in the orbit of a planet, asteroid, or comet at which it is closest to the sun
2 The point in the orbit of a planet, asteroid, or comet at which it is furthest from the sun.

Greenhouse Gases: What they are and what they do

Intergovernmental Panel on Climate Change (IPCC) defines greenhouse gases as those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the earth's surface, the atmosphere, and clouds. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary greenhouse gases in the earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine, bromine and fluorine-containing substances.



Graphical illustration of how greenhouse gases contributes towards warming. See text for more discussion.

How Greenhouse Gases Warm the Earth's Surface

The earth's surface absorbs some of the incident solar energy and reflects back some in the form of infrared radiation (heat). The energy radiated back by the earth's surface has much longer wavelength than that radiated by the sun. Greenhouse gases, which are transparent to incoming shorter-wavelength solar radiation, absorb most of the infrared radiation reflected back by the earth. This warms the atmosphere. Greenhouse gases emit absorbed infrared radiation both upwards to space and downwards to the surface. Thus, greenhouse gases trap heat within the

Principal Greenhouse Gases *(http://en.wikipedia.org/wiki/Greenhouse_gas)*

Gases	Sources	Current (1998) amount by volume	Pre-industrial revolution (1750) amount by volume	Atmospheric lifetime
CO_2	• Respiration, • Combustion of fossil fuels, • Deforestation, • Volcanism, etc.	365 ppm[3]	278 ppm	Variable: 200-250 years for small perturbations; large amount of the gas added through human activities will stay in the atmosphere for tens of thousands of years
N_2O	• Oceans, • Soil bacteria, • Nitrogen-based fertilisers, • Automobile exhaust, • Disposing of human and animal waste in sewage treatment plants, etc.	314 ppb[4]	700 ppb	120 years
CH_4	• Anaerobic decomposition of organic matter, • Livestock raising, • Coal mining, • Drilling for oil and natural gas, • Rice cultivation, • Garbage decomposition in landfills, etc.	1745 ppb	270 ppb	12 ± 3 years

3 Parts per million, 4 Parts per billion

surface-troposphere system, causing the temperature on, or near, the surface to rise.

The table demonstrates that carbon dioxide is the most widely occurring greenhouse gas in the atmosphere with the longest stay period and human beings are adding carbon dioxide more than any other gas. Gases like methane and nitrous oxide have lower atmospheric concentration and lifetime, but they have greater warming potential—methane 20 times more than carbon dioxide and nitrous oxide almost 270 times more. Another important greenhouse gas, but not mentioned in the table, is water vapour. Water vapour accounts for the largest percentage of the greenhouse effect. Its percentage in atmosphere varies according to places and seasons and it has comparatively much shorter stay period in the atmosphere, the residence time of days. Human activities do not directly affect the water vapour concentration. However, increase in temperature brought about by the increase in concentration of other greenhouse gases will scale up the concentration of water vapour. This will further increase the temperature and the concentration of water vapour, both. This is a positive feedback cycle and will continue until equilibrium is attained.

Natural Buffer against Carbon Dioxide Emissions

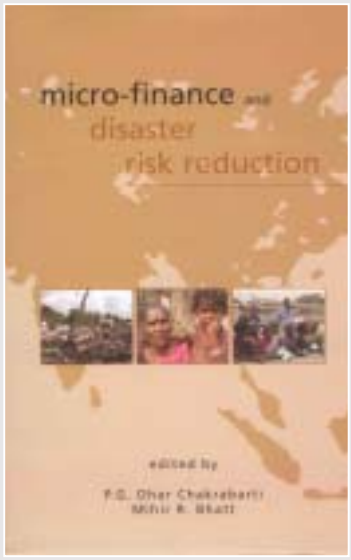
Tiny sea creatures like foraminifers, coccoliths and calcareous algae do a wonderful job for us. They lock up atmospheric carbon in their shells as the carbon falls as rain in the form of carbon dioxide. Thus, they prevent carbon dioxide from being evaporated back into the atmosphere. After they die, they fall on the bottom of the sea forming vast deposits of limestone. It is believed that earth's rocks contain almost twenty thousand times more carbon than the atmospheric carbon. The atmospheric composition and the earth's climate would be different if carbon were not locked away in the rocks.

Will Nature always protect us?

Since 1850, we have added 100 billion tonnes of extra carbon dioxide into the atmosphere at an average of about 7 billion tonnes a year, an estimate says. Nature—through volcanic outpourings and decay of plants—pumps out 200 billion tonnes of carbon dioxide each year *(Bryson, 2003)*. Our addition of carbon dioxide thus looks too little when compared with natural emission. However, the concentration of carbon dioxide in the atmosphere that was 278 ppm in 1750 has increased to 365 ppm and luckily, the temperature has increased only by 0.7ºC over the last hundred years. The effect may be too adverse to us when the natural system stops buffering us from the increased carbon dioxide concentration. When the concentration exceeds a certain threshold, the temperature may increase too rapidly for nature to buffer us from the effects. Many plants, unable to adapt to the increased heat, may die and pump out more and more carbon dioxide, further raising the temperature. ■

RESOURCES ON RISK REDUCTION AND MICROFINANCE

Resilience among the Poor through Loans, Savings and Insurance



Substantial evidence is available from across the globe that micro-finance products and services have the potential to empower the poor, particularly the poor women in rural areas, in acquiring skills, confidence and capacity to undertake activities that can significantly lift them above the poverty line.

There is also evidence that micro-credit groups of the poor have done better in coping with natural disasters although disasters like the Indian Ocean tsunami of December 2004 badly crippled their activities.

In the immediate post-disaster phase when relief and rehabilitation assistance pours in, micro-finance plays a marginal role, but when the supply of dole dries up, the poor have to fend for themselves. In this critical phase of recovery, micro-finance assumes even greater importance in supplementing other efforts for livelihood restoration and sustainable development.

This volume, which draws from the contributions in an international workshop in Delhi during 2005, is an important addition to the very limited literature available on the subject.

It is edited by **P.G. Dhar Chakrabarti**, Executive Director, National Institute of Disaster Management, New Delhi and **Mihir R. Bhatt**, Honorary Director, All India Disaster Mitigation Institute.

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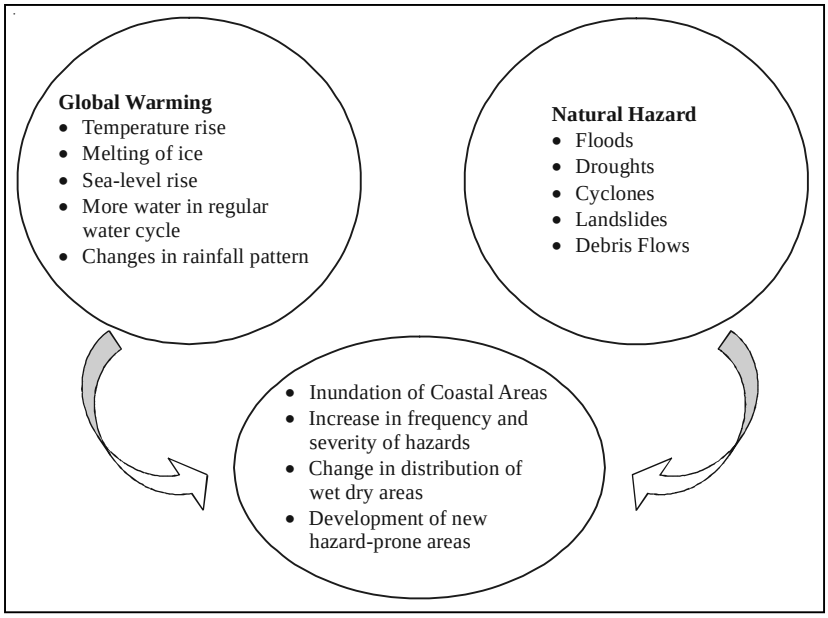
Global Warming with Asian Focus: Impact on Disasters, Diseases and Agriculture

The magnitude and frequency of hazardous processes such as floods, landslides, cyclones and droughts are subject to natural and artificially induced changes, among which climate change assumes a greater importance. Global warming observed today, for example, can cause ice to melt and sea level to rise as a result. This will bring water locked up in ice into the regular water cycle, increasing the magnitude and frequency of rainfall in various areas. The rainfall pattern and the distribution of dry and wet areas may change. New areas may become prone to hazards and the frequency and severity of hazards may change in existing hazard-prone areas. In the Asian context, climate change is especially important. South Asia is home to the world's largest number of poor. It is the poor, both countries and communities, which are at most risk to climate change and other hazards. This is due to dependence on natural resources, limited capacity to reduce risk and adapt through human, institutional, and financial measures, and rapid economic change itself. The figure on the right depicts the possible impact of global warming on natural hazards.



Graphical illustration of how global warming may influence hazard trend.

Floods

IPCC (2001) has estimated global temperature to increase by 1.5 to 6ºC by 2100. This will cause changes in the amount, intensity, duration, type and timing of precipitation, which will affect river flows and groundwater recharge. Wetherald and Manabe (2002) suggest that runoff will increase globally by about 7.3% by mid-century. Some areas will become markedly prone to reduced annual runoff, while others will see an enhancement of flow, including extreme events. The Asian Monsoon region is expected to receive increased summer precipitation. Glacial lakes in Nepal and Bhutan will expand as they accumulate more melt water and likelihood of these lakes overtopping or breaching natural dams and producing Glacial Lake Outburst Floods will increase. Flow in glacial-fed Himalayan Rivers such as Koshi, Gandaki, Karnali, Brahmaputra and Ganga will increase, but as the glaciers in the Himalaya have disappeared, the volume of river flow will be drastically reduced. This may be a serious concern for the areas drained by these Himalayan Rivers. For example, both frequency and magnitude of flooding in Bangladesh may rise because of an increased flow in the Ganges-Brahmaputra system and sea level rise. Hydroelectric generation in Nepal, India and Pakistan will be badly affected if the glaciers disappear from the Himalaya.

Droughts

Although global warming melts ice and provides the regular water cycle with increased cycle, many areas are predicted to be affected by drought. It has been indicated that by the 2080s Australia, southern Africa, northwest India, the Middle East and the

Estimated potential maximum sea-level rise from the total melting of present-day glaciers *(http://pubs.usgs.gov/fs/fs2-00/)*

Location	Volume (km^3)	Potential sea-level rise (m)
East Antarctic ice sheet	26,039,200	64.8
West Antarctic ice sheet	3,262,000	8.06
Antarctic Peninsula	227,100	.46
Greenland	2,620,000	6.55
All other ice caps, ice fields and valley glaciers	180,000	.45
Total:	32,328,300	80.32

Mud cracks developed in an area in Gujarat due to a prolonged period of drought. Global warming may cause such phenomena to occur more frequently and with increased intensity.

Mediterranean basin will show reduced levels of runoff. Some major deserts like Namib, Kalahari, Australian, Thar, Arabian, Patagonian and North Sahara may become even drier. Taklamakan of Central Asia appears to be an exception to this. Decrease in rainfall in these areas will drastically decrease rainfall and groundwater recharge in these areas with grave consequences for the inhabitants.

Coastal Hazards

After a recent cold period known as the 'Little Ice Age' in the 19th Century, sea level has been rising about 1 to 2 mm per year due to melting of ice and thermal expansion of water. The continuation of the present trend of temperature rise may melt mountain glaciers. The bulk of the earth's glaciers, however, are constituted by the Antarctic and Greenland ice sheets. The disappearance of these ice sheets will cause sea level to rise by about 80 m, whereas the rest will increase sea level by only half metre

The West Antarctic and Greenland ice sheets and mountain glaciers are considered vulnerable to melting. The West Antarctic ice sheet is grounded below sea level, and small changes in global sea level rise or a rise in ocean temperatures could cause a break-up of the two buttressing ice shelves. The Greenland ice sheet is closer to the equator than Antarctica, and thus has a higher temperature. In 1995, the IPCC estimated that the sea level by 2100 would rise 50 centimetres with the lowest estimates at 15 centimetres and the highest at 95 centimetres. This rise can increase the frequency and magnitude of coastal hazards in the areas affected by the 2004 Indian Ocean tsunami, for example.

Dialogue on Water and Climate (2003) identifies four main impacts of concern arising from sea level rise:

- Increased coastal erosion
- Flooding, inundation and displacement of wetlands and lowlands
- Impairment of water quality in freshwater aquifers and estuaries
- Reduced protection from extreme storm and flood events

Twenty per cent of the world's human population live within 30 km of the sea, and nearly double that live within the nearest 100 km of the coast. Many large cities like Jakarta and Mumbai are located near the coast and population growth rate in these cities is higher than the global average growth rate. The megacities of Asia located on subsiding deltas may be particularly vulnerable. The table below shows the effects of climate change in Bangladesh, a country mostly located on the Ganges-Brahmaputra Delta.

Human Health

Except for colder regions on the earth, global warming is predicted to have adverse impacts on human health. Health stresses and wintertime deaths will decrease in high latitude and altitude countries, but the population

Sensitivity of Bangladesh to climate change *(IPCC, 2001a)*

Change in climatic elements and Sea level rise	Vulnerable region	Primary Change	Impacts	
			Primary	Secondary
0.5-2ºC (10 to 45 cm sea level rise)	Bangladesh Sundarbans[5]	• Inundation of about 15% (~750 km^2) • Increase in salinity	• Loss of plant species • Loss of wildlife	• Economic loss • Exacerbated insecurity and loss of employment
~2ºC (5 to 10% rainfall; 45 cm sea level rise)	Bangladesh lowlands	• About 23-29% increase in extent of inundation	• Change in flood depth category • Change in monsoon rice cropping pattern	• Risk to life and property • Increased health problems • Reduction in rice yield

5 A region of swampland in the Ganges delta, extending from the mouth of the River Hooghly in West Bengal to that of the Tetulia in Bangladesh.

in tropical, temperate, and arid and semiarid regions may suffer from diseases associated with heat waves and increased humidity. Malaria is already an important disease in countries like India, Sri Lanka, Thailand and Indonesia. Rise in surface temperature and changes in rainfall patterns can expand spread of vector-borne diseases into temperate and arid Asia. Depletion of stratospheric ozone is also likely to increase skin and eye diseases. Higher sea surface temperature and rich nutrient load in major river deltas may support extended phytoplankton blooms in selected coastal areas of temperate and tropical Asia. These phytoplankton blooms are habitats for the survival and spread of infectious bacterial diseases. The cholera outbreak in Bangladesh during 1994 has been attributed to the presence of extended phytoplankton blooms *(IPCC, 2001)*.

Agriculture

Like diseases, impact of global warming will have mixed results in Asia. Areas in northern Asia will enjoy increased crop yield due to raised temperature and carbon dioxide concentration, but lower latitude areas may face decrease in agricultural production. The area under wheat cultivation is likely to expand in north and west Asia. However, in tropical Asia including India, rice production may decline. Acute water shortage conditions combined with thermal stress may adversely affect wheat production in India as well. Study conducted for different Asian countries such as Bangladesh, China, India, Indonesia, Japan, Malaysia and Thailand demonstrates that rice production in these countries will be decreased if surface air temperature rises by 4ºC or more. However, enhanced photosynthesis owing to increased carbon dioxide concentration can offset and increase rice production in those countries if surface temperature rises by 2ºC or less *(Mathews et al., 1995)*. In addition to temperature and carbon dioxide concentration rise, changed pattern of soil moisture evaporation; rainfall intensity, timing and duration; spells of wet and dry periods; disasters; and so on will also influence the crop production. Asia has the world's largest area under cereal cultivation *(FAO, 1999)* and any change in agricultural productivity in the continent will have a global influence. ■

Changes in sea level, sea temperature and ocean currents may alter the distribution of oceanic biodiversity and affect coastal communities relying upon it.

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Adaptation to Climate Change: Options for Asia

Owing to existing vulnerabilities, the poor of Asia are likely to suffer a great deal from the negative impacts of climate change. The impacts may be grouped into two general classes:

- Changes in magnitude and frequency of climatic extremes, which may affect the trend of hydrometeorological hazards
- Changes in average climatic conditions, which may alter underlying vulnerabilities of the community

Thus, global warming will affect the magnitude and frequency of hazards as well as different sectors of economy such as agriculture, water resources, coastal resources and human health. The following paragraphs discuss opportunities outlined by IPCC that may be helpful for different regions of Asia in adapting to climate change-induced losses.

Summary of Potential Sector-Wide Adaptation Options for Asia:
Agriculture

- *Boreal Asia:* Adopt suitable crops and cultivars; make optimum use of fertilisers and adaptation of agro-technologies.
- *Arid and Semi-Arid Asia:* Shift from conventional crops to intensive greenhouse agriculture / aquaculture; protect against soil degradation.
- *Temperate Asia:* Adopt heat-resistant crops, water-efficient cultivars with resistance to pests and diseases, soil conservation.
- *Tropical Asia:* Adjust cropping calendar and crop rotation; develop and promote use of high-yielding varieties and sustainable technological applications.

Water Resources

- *Boreal Asia:* Develop flood-protection systems in north Asia (required because of permafrost melting and increased streamflow volume / surface runoff); enhance management of international rivers.
- *Arid and Semi-Arid Asia:* Enhance conservation of freshwater supply as option for extreme water-stress conditions.
- *Temperate Asia:* Flood and drought control measures required; improve flood warning and forecasting systems.
- *Tropical Asia:* Develop flood- and drought-control management systems; reduce future developments in floodplains; use appropriate measures for protection against soil erosion; conserve groundwater supply, water impoundments, and efficient water resource systems.

Ecosystems and Biodiversity

- Assess risks to endemic species and ecosystems.
- Introduce integrated ecosystem planning and management.
- Reduce habitat fragmentation and promote development of migration corridors and buffer zones.
- Encourage mixed-use strategies.
- Prevent deforestation and conserve natural habitats in climatic transition zones inhabited by genetic biodiversity of potential for ecosystem restoration.

Coastal Resources

- *Boreal Asia:* Modify infrastructure to accommodate sea-level rise.
- *Arid and Semi-Arid Asia:* Protect lakes and water reservoirs; develop aquaculture farming techniques.
- *Temperate Asia:* Follow setback examples for new coastal development; evaluate coastal subsidence rates in sensitive coastal regions; prepare contingency plans for migration in response to sea-level rise; improve emergency preparedness for weather extremes (e.g., typhoons and storm surges).
- *Tropical Asia:* Protect wetlands and allow for migration; prepare contingency plans for migration in response to sea-level rise; improve emergency preparedness for weather extremes; evaluate coastal subsidence rates in sensitive coastal regions.

Human Health

- Build heat-resistant urban infrastructure and take additional measures to reduce air and water pollution.
- Adapt technological / engineering solutions to prevent vector-borne diseases / epidemics.
- Improve health care system, including surveillance, monitoring, and information dissemination.
- Improve public education and literacy rate in various communities.
- Increase infrastructure for waste disposal.
- Improve sanitation facilities in developing countries.

Cross-Cutting Issues

- Continue monitoring and analysis of variability and trends in key climatic elements.
- Improve weather forecasting systems in the region.
- Improve and implement reforms on land-use planning.
- Apply new techniques for confident projection of regional climate change and its variability, including extreme events.
- Improve coordination of climate change adaptation activities among countries in the region.
- Keep the NGO community and the public aware of developments on risks of climate change and involve them in planning, adaptation, and mitigation strategies.
- Take advantage of traditional knowledge in planning for the future. ■

Recent Policies towards Global Warming: Selected International Organisations

Recognition that the observed trend of global warming may bring severe results to humankind is reflected in policies and activities of key international organisations. Targets have been set and activities have been designed to decrease the production of greenhouse gases. However, disasters are not always well addressed in such policies. This article summarises the climate change policies of some key institutions like the European Union (EU), the world Bank, UK Department for International Development (DFID) and International Federation of Red Cross and Red Crescent Societies (IFRC).

This type of emmission produced by factories can have severe implications for humankind. The decision to reduce the release of greenhouses into the atmosphere is a welcome approach. (Source: www.millergoodall.co.uk)

European Union

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) is only a first step to address the serious global threat of climate change. The ultimate goal of the UNFCCC is to stabilise atmospheric concentrations of greenhouse gases at a level that prevents dangerous human interference with the climate system. There is considerable scientific evidence, from the Intergovernmental Panel on Climate Change (IPCC) and others, that worldwide emissions of greenhouse gases will need to be reduced to well below 1990 levels in order to meet this goal.

On 10 January 2007 the European Commission set out proposals and options for keeping climate change to manageable levels in its Communication "Limiting Global Climate Change to 2° Celsius: The way ahead for 2020 and beyond."

The Communication, part of a comprehensive package of measures to establish a new energy policy for Europe, is a major contribution to the ongoing discussions at international level on a future global agreement to combat climate change after 2012, when the Kyoto Protocol's emissions targets expire.

The Communication proposes a set of actions by developed and developing countries that would enable the world to limit global warming to no more than 2°C above pre-industrial temperatures. The key elements of the Communication were endorsed by EU Environment Ministers on 20 February 2007 *(http://www.euractiv.com/en/sustainability/eu-climate-change-policies/).*

World Bank

Climate change has emerged as a key concern for the World Bank and its clients in the 21st century. Sea level rise, warming temperatures, uncertain effects on forest and agricultural systems, and increased variability and volatility in weather patterns are expected to have a significant and disproportionate impact in the developing world, where the world's poor remain most susceptible to the potential damages and uncertainties inherent in a changing climate.

The Bank is increasingly incorporating these considerations into its development operations, advising clients on options, helping promote sectoral efficiency and clean energy alternatives, and assisting its clients in adapting to foreseeable impacts while seeking globally equitable responses to the challenge *(http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/ENVIRONMENT/EXTCC/).*

Asian Development Bank

Energy is a vital input to economic growth and poverty reduction. In the last 30 years, productivity and wealth have grown rapidly in Asia and the Pacific and, consequently, so has dependence on energy.

The region's energy needs are primarily fulfilled by fossil fuels, the increased consumption of which has negative economic and environmental impacts. By depending on fossil fuels, countries are exposed to oil price and supply fluctuations that undermine

their energy security. Furthermore, the combustion of fossil fuels creates large amounts of greenhouse gas (GHG) emissions, thereby damaging the atmosphere and contributing to climate change.

It is, however, possible to improve energy security and reduce GHG emissions by implementing energy efficiency measures and seeking alternative sources of energy without sacrificing economic growth and living standards.

The Asian Development Bank emphasises the acceleration of the widespread application of renewable energy and energy efficiency in its developing member countries (DMCs). However, although many of ADB's DMCs have established country-level legislation and targets, there are significant barriers to mainstreaming the application of clean energy technologies and services.

ADB is systematically studying these barriers to focus its interventions primarily on developing and enabling environment—policy, regulatory, tariff, institutional—and to facilitate the preparation and implementation of more clean energy projects. ADB is also working toward enhancing awareness on renewable energy and energy efficiency opportunities through country-based capacity-building initiatives, as well as taking advantage of the growing carbon market *(http://www.adb.org/Clean-Energy/default.asp)*.

Department for International Development

DFID has developed a key sheet as part of a series aimed at DFID staff and development partners examining the impact of climate change on poverty. The sheet draws on experience in disaster management and social protection to explore ways of reducing the impact of climate change on the poor. It aims to guide the reader through the key issues of:

- Natural disasters and climate change
- Disaster management and climate variability
- Disaster management and climate change
- Frameworks for the integration of climate risk responses

Lastly, the sheet advises on the way forward in using disaster management as part of adaptation to climate change *(http://www.dfid.gov.uk/pubs/files/climatechange%5C6disasterproof.pdf)*.

International Federation of Red Cross and Red Crescent Societies

In response to the growing concerns regarding climate change, in June 2002 the Netherlands Red Cross officially launched the International Red Cross Red Crescent Centre on Climate Change and Disaster Preparedness. The centre will address the threat millions of people face from climate change related disasters every year by seeking to bridge the gap between meteorological science and relief aid.

The Climate Centre supports National Red Cross and Red Crescent Societies to eventually reduce the loss of life and the damage done to the livelihoods of people affected by the impacts of climate change and extreme weather events. The Climate Centre is based in the Netherlands but serves the whole Red Cross / Red Crescent Movement, in particular in developing countries. There is a close co-operation with the secretariat of the International Federation of Red Cross and Red Crescent Societies in Geneva *(http://www.ifrc.org/what/disasters/dp/climate/centre.asp and http://www.climatecentre.org/)*. ■

Unpredictable Nature: Tambora Explosion

In 1815, on the island of Sumbawa in Indonesia, a handsome and long quiescent mountain named Tambora exploded spectacularly, killing a hundred thousand people with its blast and associated tsunamis. No-one living now has ever seen such fury. Tambora was far bigger than anything any living human has experienced. It was the biggest volcanic explosion in ten thousand years — 150 times the size of Mount St Helens, equivalent to sixty thousand Hiroshima-sized atom bombs.

News did not travel terribly fast in those days. In London, *The Times* run a small story—actually a letter from a merchant—seven months after the event. But, by this time, Tambora's effects were already being felt. Two hundred and forty cubic kilometres of smoky ash, dust and grit had diffused through the atmosphere, obscuring the Sun's rays and causing the Earth to cool. Sunsets were unusually but blearily colourful, an effect memorably captured by the artist J. M. W. Turner, who could not have been happier, but mostly the world existed under an oppressive, dusky pall. It was this deathly dimness that inspired Bryon to write the lines quoted above.

Spring never came and summer never warmed: 1816 became known as the year without summer. Crops every-where failed to grow. In Ireland a famine and associated typhoid epidemic killed sixty-five thousand people. In New England, the year became popularly known as Eighteen Hundred and Froze to Death. Morning frosts continued until June and almost no planted seed would grow. Short of fodder, livestock died or had to be prematurely slaughtered. In every way, it was a dreadful year — almost certainly the worst for farmers in modern times. Yet, globally the temperature fell by less than 1 degree Celsius. The Earth's natural thermostat, as scientists would learn, is an exceedingly delicate instrument. *(Excerpted from Bryson, 2003)*

Weather Insurance Mitigates Risk: A Case Study of Good Practice from Malawi

The following article discusses USAID-supported weather insurance practice in Malawi, which may be useful to farmers in other parts of the world to mitigate the impact of adverse weather on agriculture.

In response to food insecurity brought on by drought, lack of irrigation, and resulting poor crop yields, organisations in Malawi have developed innovative ways to protect farmers and their families.

Peanut farmers in Malawi have traditionally relied on local seed for production. In hopes of producing greater yields and a more competitive product, however, some farmers have become interested in planting an improved seed variety. Unfortunately, these farmers have had little cash and no access to finance to purchase the high-quality seed; banks have been unwilling to lend to them, primarily because of the significant risk of default in the event of a drought.

In an effort to make these farmers more creditworthy and able to access loans for high-quality seed, the National Smallholder Farmers' Association of Malawi, in conjunction with the Insurance Association of Malawi, designed an index-based weather insurance policy that covers farmers if rainfall is insufficient. Technical assistance was provided by the World Bank and Opportunity International.

Weather insurance mitigates the most significant risk associated with lending to peanut farmers. OIBM and Malawi Rural Finance Corporation agreed to provide loans to farmers for high-quality seed if the farmers bought the insurance. In four pilot districts, 892 farmers purchased the weather insurance.

Not only a benefit to farmers, weather insurance also allows the participating banks to expand their lending portfolio while mitigating their risk. This pilot reflects the Government of Malawi's initiative and leadership in exploring innovative ways to manage weather and price risk in Malawi through ex-post planning and financing. The Government plans to extend coverage to maise farmers as well as more peanut farmers in other parts of the country. If it can be scaled-up to additional crops and farmers in Malawi, index-based weather insurance could help farmers not only manage their risk but also invest in their farms.

A family has put clay bags to prevent water entering their house. Can local knowledge like this be enhanced for climate change adaptation?

Several prerequisites have made this project a success thus far in Malawi:

- Accredited weather stations that have data for 30 to 40 years and are able and willing to provide data to stakeholders during the contract period
- Farmers located within a 10 to 20 kilometer radius of the station
- Willing lenders, such as OIBM, with experienced staff
- Willing farmers
- A farmers association or other body to help mobilise the farmers
- Insurers that are willing to write non-conventional covers; in this case one of the roles performed by Opportunity International was to underwrite and price the insurance products for local insurers
- Project coordinator with relevant insurance background
- A donor (World Bank) to provide technical assistance and work with the project coordinator

USAID currently funds a cooperative agreement with Opportunity International to help with the establishment of OIBM and to increase outreach of financial services to the rural areas in Malawi. OIBM received additional support and funding from the World Bank to build on its rural outreach efforts through the Weather Insurance Pilot.[6] ■

6 Based on: Kimball, R., 2006. Weather Insurance Mitigates Risk. USAID (can be downloaded from http://www.microlinks.org/ev_en.php?ID=10539-201&ID2=DO_REDIRECT2

Good Practice: Civil Society Organisations and Climate Change Adaptation

Although there is a lot to understand about climate change and its impact, science has made a significant advancement on the subject. Several civil society organisations rooted in the community have drawn from the scientific developments on climate change and designed projects to reduce community risks arising from the change. The following paragraphs share good practice by the World Conservation Union (IUCN) in Sri Lanka and Thailand.

Achieving Environmental Awareness and Progress through Multi-layered Cooperation: IUCN in Sri Lanka and Thailand

The IUCN has carried out numerous programmes, ranging from cleaning beaches and reefs and rapid biodiversity and socio-economic surveys in affected areas to creating greater environmental awareness at both local and national levels.

IUCN cooperates with local and national partners, governments and NGOs, as well as the private sector. In the South Asia region, IUCN is implementing more than 130 projects. The Union has 157 members, government and non-government agencies, in 19 countries in South and South East Asia.

In Thailand and Sri Lanka in particular, work on ecological and social assessments has proved useful to other organisations and government agencies involved in post-tsunami rehabilitation.

Since the tsunami, the World Conservation Union, its members and its partners have been very active, providing guidance to reconstruction efforts and undertaking community-based restoration work in affected areas in the Asian and African region, particularly along the coasts of Sri Lanka and Thailand. It has also provided guidance and support on ecosystems and sustainable livelihood to the wide range of agencies and sectors that are involved in post-tsunami reconstruction across the region.

Coastal ecosystems and wetlands, as well as key marine ecosystems such as coral reefs and sea grass beds, suffered seriously in the Tsunami. Their loss also reduced the options for people to rebuild their livelihoods.

Mandated to value a just world that conserves people and nature, the Union took the approach that sustainable reconstruction must build on a healthy environment, and that livelihoods will only be sustainable if ecosystems are restored and conserved. One of the main factors of IUCN's success was its wide network of members, partners and scientific experts.

Sri Lanka

The World Conservation Union, in collaboration with the Government of Sri Lanka, local government authorities, NGOs and community organisations restored coastal livelihoods in the Hambantota district. This included the construction of a cold room for the storage of fish, donation of boats and nets, restoration of home-gardens, construction of fuel-efficient cook stoves and grants for the rebuilding of small sales kiosks.

The tsunami did enormous damage to the ecosystem in Negombo estuary in Sri Lanka, which resulted in severe hardship to the local people. Furthermore, sand dunes that have acted as natural barriers, protecting the homes of 300,000 people, are now under severe pressure, due to indiscriminate sand mining. Together with the project Green Coast for Nature and People after the Tsunami, the World Conservation Union has been engaged in enhancing the quality of life of affected communities by improving the productivity and sustainability of the Negombo lagoon and the adjacent Muthurajawela marshes.

Thailand

In the aftermath of the tsunami, restoring sustainable livelihoods required restoring the environment. Post-tsunami reconstruction was aimed at preparing the resettlement of over a hundred families. However, recognising the possible environmental effects of reconstruction, the Swiss Agency for Development and Cooperation, who built boats, houses and social infrastructure, requested the World Conservation Union to ensure that environmental concerns were taken into consideration. As part of this cooperation, the World Conservation Union also discovered that there was a need to empower communities to recover, and to identify further livelihood opportunities, ranging from fishing, raising livestock and organic farming, to eco-tourism activities.

Working together with other NGOs makes it easier to come to good results and work towards achieving what the affected population needs. Knowing what those needs are becomes easier when representatives of the population are involved- i.e., the local government. The shift from mandate-centred aid to need-based aid is therefore greatly helped by close cooperation between all parties involved. ■

Implications of Climate Change for Poverty Eradication

Changes in mean climate variability, extreme events and sea level rise	Increase in vulnerability of the poor	Millennium Development Goals
Increased temperature and changes in precipitation reduces AGRICULTURAL and NATURAL RESOURCES	LESS SECURE LIVELIHOODS (due to depleted social, financial, physical, natural resource and human assets and increased displacement of people)	Goal 1: Eradicate extreme poverty and hunger
Change in precipitation, run-off and variability leads to greater WATER STRESS	INCREASED HEALTH RISKS (Malaria, Dengue, Cholera, Dysentery, Malnutrition, Exposure)	Goal 2: Achieve Universal Primary Education
Increased incidence or intensity of climate related disasters leads to damage to INFRASTRUCTURE	CONSTRAINED ECONOMIC OPPORTUNITIES (Short and long term impacts of droughts and extreme events)	Goal 3: Promotes Gender Equality
Temperature, water and vegetation changes contribute to INCREASED PREVALENCE OF DISEASE		Goal 4: Reduce Child Mortality
		Goal 5: Improve Maternal Health
		Goal 6: Combat Major Diseases
		Goal 7: Ensure environmental sustainability
		Goal 8: Promote Global Partnerships

Source: Ajay Mathur: World Bank

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