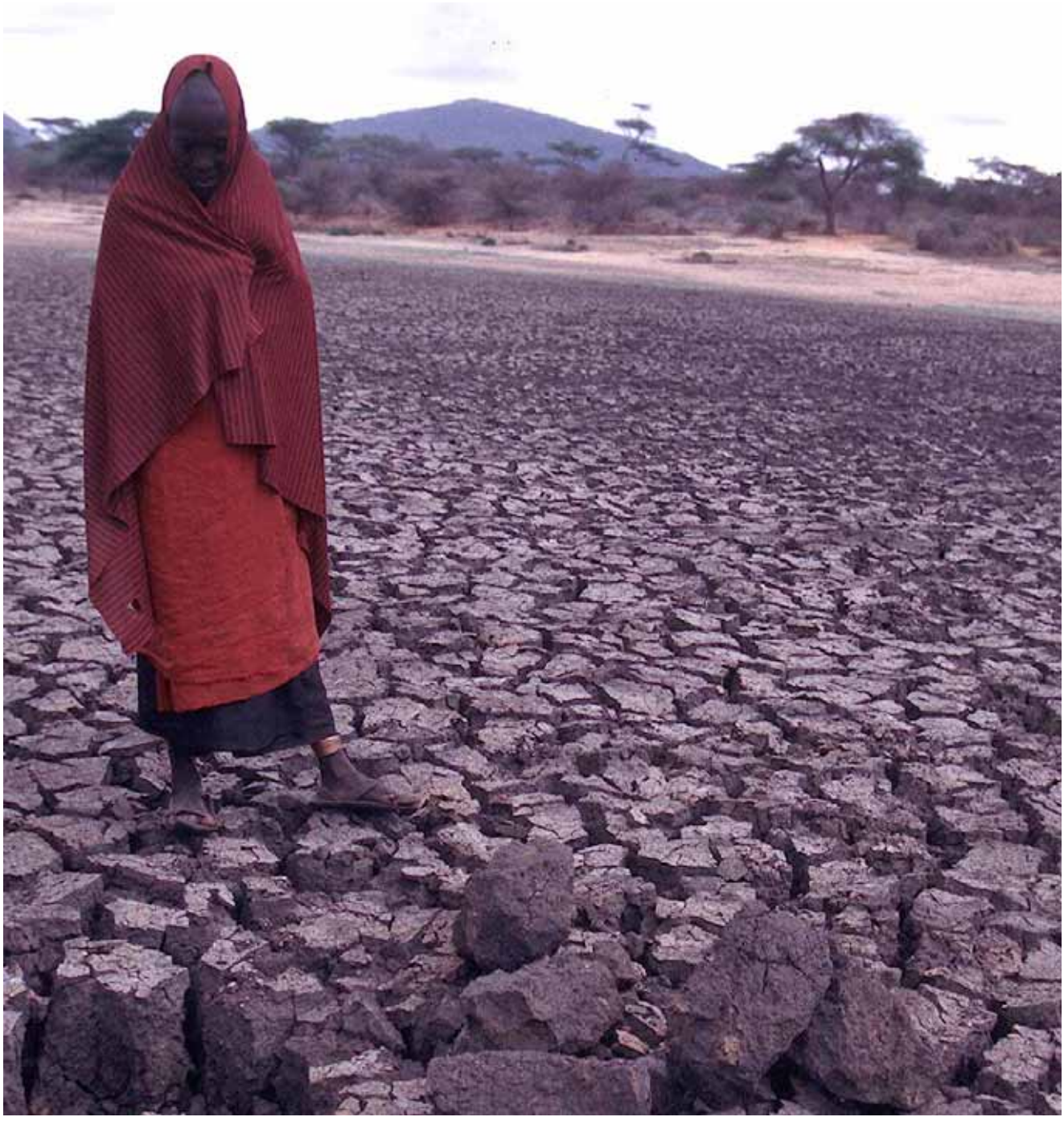
Climate change and water resources



Credit: WaterAid / Jim Holmes

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1 WHAT IS CLIMATE CHANGE?

1.1 INTRODUCTION

Scientists around the world now agree that the climatic changes occurring internationally are the result of human activity. Although responsibility for the causes of climate change rests primarily with the developed and industrialised nations, the costs of climate change will be borne most directly by the poor. This is for a number of reasons, including:

- many of the regions most likely to be adversely affected fall in the developing world;
- the poor are disproportionately dependent on occupations, such as farming, that are adversely affected by climate change; and
- because the poor have very limited resources, they do not have the ability to adapt to climate change in the way that wealthier households can.

In particular, changes to water quality, quantity and availability will be an impact of ongoing climate change in many areas.

This paper describes what climate change is, including how it is affecting the world we live in and the timeframe within which these changes are expected to happen. It then considers why climate change needs to be a priority in development planning, including the inequitable burden it places on the poor and developing countries, as well as the impacts on the world's water resources. Finally, this paper concludes by presenting measures to address climate change, including some current campaigns.

1.2 WHAT IS CLIMATE CHANGE?

The United Nations Framework Convention on Climate Change (UNFCCC, see *box 2.1)* defines climate change as, "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". [1]

(1) United Nations Framework Convention on Climate Change, United Nations, 1992 (p. 3)

The United Nations Framework Convention on Climate Change (UNFCCC) was convened in 1992 with an overarching framework to address the challenges of climate change through intergovernmental efforts.

The objectives of the UNFCCC are:

1. To stabilise greenhouse gas concentrations to levels that prevent dangerous interference with the global climate system; and
2. To achieve these reductions within a time frame that allows ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner.

The Kyoto Protocol was developed in 1997 to reinforce the emissions reduction commitments of the UNFCCC. The Protocol came into legal force in 2005 when it was ratified by 30 industrialised nations, creating legally binding targets for a 5 percent reduction in emissions below 1990 levels by 2012.

Box 0.1 The international process on climate change

Climate change is caused by greenhouse gasses (GHGs), which enhance the "greenhouse" properties of the earth's atmosphere. These gasses allow solar radiation from the sun to travel through the atmosphere but prevent the reflected heat from escaping back into space. This causes the earth's temperature to rise.

GHG emissions have been rising since industrialisation in the 1900s, due to increased burning of fossil fuels. Further significant increases in GHG levels are expected, particularly as developing countries become more industrialised. Based on present trends, the IEA World Energy Outlook predicts a 53 percent increase in global primary energy demand by 2030, with 70 percent of that coming from developing countries. As emerging economies, such as China and India, grow their contribution to energy demand will account for an increasing proportion of the total. Fossil fuels are expected to dominate this increase, and the subsequent GHG emissions will in turn lead to rising temperatures.

The EU has defined dangerous climate change as an increase in 2 degrees Celsius of average global temperatures. Since 1900, global temperatures have risen by 0.7 degrees Celsius and are continuing to rise at an estimated rate of 0.2 degrees per decade. If left unchecked, this implies global warming of at least 1.4 degrees Celsius. [2]

More recent scientific research finds that these temperature projections are actually much higher than previously thought. GHG emissions are not remaining stable – they are increasing due to increased energy consumption as a result of population growth and industrialisation. From a pre-industrial concentration of 280 ppm, the current stock of greenhouse gases in the atmosphere is 430 ppm, and is increasing by approximately 2.5 ppm per year. Even if the world's GHG emissions stabilise at 550 ppm, it is estimated that, *at a minimum*, there is a 63

(2) IPCC, Climate Change 2001: The Scientific Basis

percent chance of exceeding the declared 'dangerous' limit of 2 degrees Celsius temperature increase. [3]

The effects of climate change on temperature are demonstrated by the "Hockey Stick" graph (see Figure 2.1). The graph, which measures temperature variation over the last 1,000 years, indicates a sharp rise in temperatures post-1900. The graph has been used to illustrate the urgent need for action on reducing GHGs to policymakers.

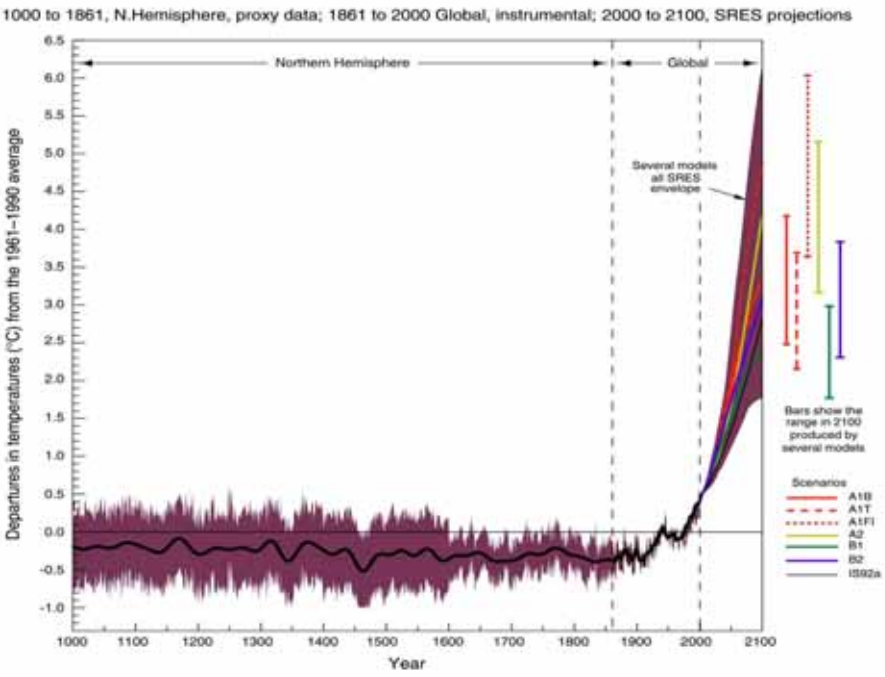


Figure 0.1 Hockey Stick graph

1.3 HOW FAST IS CLIMATE CHANGE OCCURRING?

In 2005, the conference "Avoiding Dangerous Climate Change" [4] raised concern that climate change is occurring more quickly than previously anticipated. Among the key findings of the conference were:

- Future emissions of greenhouse gases will raise temperatures by 1.4 to 5.8 degrees Celsius during this century.
- A change in ocean acidity is likely to reduce the ocean's capacity to absorb CO_2 from the atmosphere, thus compounding the effects of climate change, and will affect the entire marine food chain.
- Large-scale, irreversible system disruption and the destabilisation of the Antarctic ice sheets are serious risks: changes to polar ice, glaciers and rainfall regimes have already occurred.

(3) The Stern Review on the Economics of Climate Change, HM Treasury. Available at: http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm. Chapter 8

(4) Defra, 2005. http://www.defra.gov.uk/environment/climatechange/internat/dangerous-cc.htm

Concerns over the pace of climate change are compounded by two mechanisms – known as non-linear biophysical changes and positive feedback mechanisms – which could further accelerate the damages caused by climate change.

Non-linear biophysical changes refer to the risk of sudden or extreme climate changes, caused by the physical and biological factors that influence the earth's climate.

Similarly, climate change can be further accelerated by positive feedback mechanisms. For example, at a certain threshold, the ability of the ocean (as highlighted above), as well as soil and plants, to absorb CO_2 (currently considered a carbon "sink") may reduce or even reverse, thus removing an important source of carbon storage. Estimates suggest that by 2100, positive feedback mechanisms could lead to an additional rise in temperatures 1 – 2 degrees higher than what is already expected from the direct warming caused by greenhouse gas emissions.[5]

(5) The Stern Review on the Economics of Climate Change, HM Treasury. Available at: http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm.

2 WHAT ARE THE PREDICTED IMPACTS OF CLIMATE CHANGE?

2.1 OVERVIEW

Estimates of the predicted impacts of climate change vary, with assessments of future global temperatures differing between 1.4 and 5.8 degrees Celsius. However, despite these variances, even the minimum predicted shifts in climate for the 21st century are likely to be significant and disruptive, while changes at the higher end of the spectrum could be catastrophic.

2.2 THE IMPACTS OF CLIMATE CHANGE ON CRITICAL AREAS

The effects of minor levels of climate change are already being felt, with impacts across many economic sectors. While there will clearly be some gains from climate change (for example, agriculture in some northern regions should increase in productivity due to a rise in temperatures), most of the impacts will be negative, and gains and losses will not be evenly distributed. For example:

- *Water*: Rising global temperatures will lead to an intensification of the hydrological cycle, resulting in dryer dry seasons and wetter rainy seasons, and subsequently heightened risks of more extreme and frequent floods and drought. Changing climate will also have significant impacts on the availability of water, as well as the quality and quantity of water that is available and accessible. Melting glaciers will increase flood risk during the rainy season, and strongly reduce dry-season water supplies to one-sixth of the World's population.

- *Agriculture*: Declining crop yields are likely to leave hundreds of millions without the ability to produce or purchase sufficient food supplies, especially in Africa. At mid to high latitudes, crop yields may increase for low levels of change in temperature, but will decline at higher levels of temperature change.

- *Ecosystems*: Changing temperatures will cause ecosystems to shift – forests, land types and plant species will dieback in some areas as temperatures rise, but increase in other areas. However, in many cases, the pace of change in temperature may be too fast for ecosystems to adjust, resulting in the loss of forests and species.

- *Health*: Higher temperatures expand the range of some dangerous vector-borne diseases, such as malaria, which already kills one million people annually, most of whom are children in the developing world. Further, heat waves associated with climate change, and increases in water borne diseases, will result in increased health problems.

- *Coastlines*: Melting ice and thermal expansion of oceans are the key factors driving sea level rise. In addition to exposing coastlines, where the majority of the human population live, to greater erosion and flooding pressures, rising sea levels will also lead to salt water contamination of groundwater supplies, threatening the quality and quantity of

freshwater access to large percentages of the population.[6] For example, according to some estimates a 1 metre rise in sea level will displace 80 percent of the population of Guyana.[7]

Box 2.1 illustrates some of the regional impacts that are expected to result from climate change.

- Latin America: temperatures are predicted to increase by between 0.2- 2 degrees Celsius (low estimate) to 2- 6 degrees Celsius (high estimate) in the next century. El Niño events will increase in frequency and severity during summer months, and some areas will experience hot and cold waves.
- Africa: greater climate variability, and increasing frequency and intensity of severe weather over the next 50 years. The northern and southern latitudes will become dryer and the tropics will become wetter.
- Asia: summer and winter temperatures rise by 0.1- 0.2 degrees per decade over the next 10-20 years. Heavy rainfall and cyclone intensity may increase due to disruption of the El Niño cycle and increasing sea surface temperatures.

Source: DFID Keysheets on Climate Change and Poverty, http://www.dfid.gov.uk/pubs/files/climatechange/keysheetsindex.asp

Box 2.1 Anticipated regional impacts of climate change in Africa, Asia, and Latin America

Table 2.1 provides more detail on the kinds of impacts that are predicted to occur at different increases in global average temperatures.

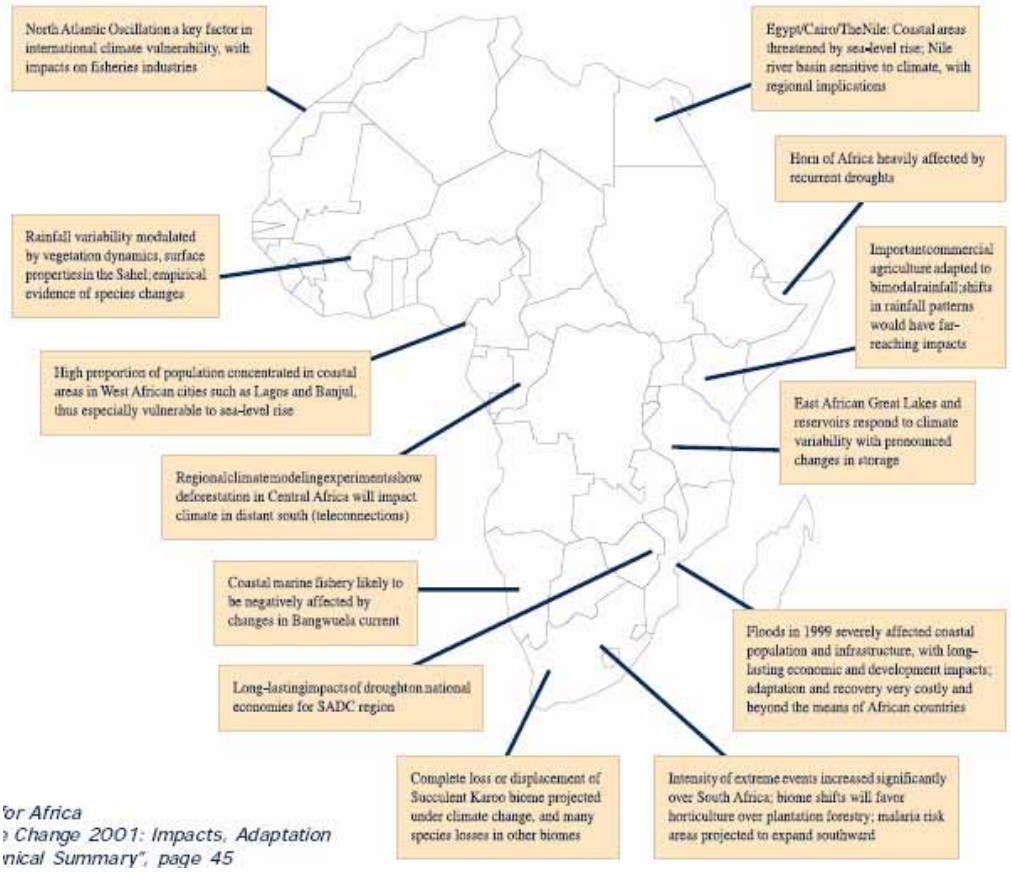
(6) Stern Review, Chapter 3
(7) Smith, D.M. Just One Planet: Poverty, Justice and Climate Change. UK: Practical Action Publishing, 2006 p.72

Table 2.1 Highlights of possible climate impacts

Temp rise (°C)	Water	Food	Health	Land	Environment	Abrupt and Large-Scale Impacts
1°C	Small glaciers in the Andes disappear completely, threatening water supplies for 50 million people	Modest increases in cereal yields in temperate regions	At least 300,000 people each year die from climate related diseases (predominantly diarrhoea, malaria, and malnutrition) Reduction in winter mortality in higher latitudes (Northern Europe, USA)	Permafrost thawing damages buildings and roads in parts of Canada and Russia	At least 10 percent of land species facing extinction (according to one estimate) 80 percent bleaching of coral reefs, including Great Barrier Reef	Atlantic Thermohaline Circulation starts to weaken
2°C	Potentially 20 - 30 percent decrease in water availability in some vulnerable regions, e.g. Southern Africa and Mediterranean	Sharp declines in crop yield in tropical regions (5 - 10 percent in Africa)	40 – 60 million more people exposed to malaria in Africa	Up to 10 million more people affected by coastal flooding each year	15 – 40 percent of species facing extinction (according to one estimate). High risk of extinction of Arctic species, including polar bear and caribou	Potential for Greenland ice sheet to begin melting irreversibly, accelerating sea level rise and committing world to an eventual 7m sea level rise. Rising risk of abrupt changes to atmospheric circulations, e.g. the monsoon.
3°C	In Southern Europe, serious droughts occur once every 10 years 1 – 4 billion more people suffer water shortages, while 1 – 5 billion gain water, which may increase flood risk	150 - 550 additional millions at risk of hunger (if carbon fertilisation weak) Agricultural yields in higher latitudes likely to peak	1 – 3 million more people die from malnutrition (if carbon fertilisation weak)	1 – 170 million more people affected by coastal flooding each year	20 – 50 percent of species facing extinction (according to one estimate), including 25 – 60 percent mammals, 30 – 40 percent birds and 15 – 70 percent butterflies in South Africa. Onset of Amazon forest collapse (some models only)	
4°C	Potentially 30 -50 percent decrease in water availability in Southern Africa and Mediterranean	Agricultural yields decline by 15- 35 percent in Africa, and entire regions out of production (e.g. parts of Australia)	Up to 80 million more people exposed to malaria in Africa	7 – 300 million more people affected by coastal flooding each year	Loss of around half Arctic tundra. Around half of all the world's nature reserves cannot fulfil objectives	
5°C	Possible disappearance of large glaciers in Himalayas, affecting one-quarter of China's population and hundreds of millions in India	Continued increase in ocean acidity seriously disrupting marine ecosystems and possibly fish stocks		Sea level rise threatens small islands, low-lying coastal areas (Florida) and major world cities such as New York, London, and Tokyo		
More than 5°C	The latest science suggests that the Earth's average temperature will rise by even more than 5 or 6°C if emissions continue to grow and positive feedbacks amplify the warming effect of greenhouse gases (e.g. release of carbon dioxide from soils or methane from permafrost). This level of global temperature rise would be equivalent to the amount of warming that occurred between the last age and today – and is likely to lead to major disruption and large-scale movement of population. Such "socially contingent" effects could be catastrophic, but are currently very hard to capture with current models as temperatures would be so far outside human experience.					

Notes:
As colours move from yellow to red, they indicate increasing severity of impacts.
This table shows illustrative impacts at different degrees of warming. Some of the uncertainty is captured in the ranges shown, but there will be additional uncertainties about the exact size of impacts (more detail in Box 3.2). Temperatures represent increases relative to pre-industrial levels. At each temperature, the impacts are expressed for a 1°C band around the central temperature, e.g. 1°C represents the range 0.5 – 1.5°C etc. Numbers of people affected at different temperatures assume population and GDP scenarios for the 2080s from the Intergovernmental Panel on Climate Change (IPCC). Figures generally assume adaptation at the level of an individual or firm, but not economy-wide adaptations due to policy intervention (covered in Part V).
Source: Stern Review, Chapter 3.

Figure 2.1 Examples of impacts from climate change in Africa



'or Africa
e Change 2001: Impacts, Adaptation
nical Summary", page 45

Source: IPCC, Climate Change 2001: Impacts, Adaptation and Vulnerability p. 45

Table 2.2 Examples of climate change impacts in Asia

Boreal Asia	• Expanded agricultural growing season • Increased active soil temperatures/ better soil climate • Northward shift of agricultural boundary • Change to timing of snowmelt and therefore altered flow regime • Decrease in dry summer season water flow
Arid & Semi-Arid Asia	• Exacerbation of threats caused by land use/ cover change & population pressures • Significant increase in surface air temperatures • Increased evapotranspiration in plants • Acute water shortages
Temperate Asia	• Significant surface warming & rainfall pattern shifts • Increased plant respiration & saturation deficits, decreased agricultural productivity • Intensification of climatic hazards (e.g. floods, droughts, sea level rise, storm surges
Tropical Asia	• Changes to hydrological regime • Increased flooding, water logging, salinity caused by higher runoff in some river basins • Decreased surface runoff in some basins due to increased evaporation • Changes in freshwater availability in coastal regions • Sea level rise, leading to inundation of low-lying areas, shoreline retreat, changes to water table, salinisation/ acidification of soil

Source: IPCC, Climate Change 2001: Impacts, Adaptation and Vulnerability

2.3 CLIMATE CHANGE AND THE HYDROLOGICAL CYCLE

2.3.1 Introduction

Because much of the solar energy received by the Earth is used to drive the hydrological cycle, higher levels of solar energy trapped in the atmosphere will lead to an intensification of this cycle, resulting in changes in precipitation patters. These changes will result in increased floods and drought, which will have significant impacts on the availability of freshwater. These impacts on freshwater will be further compounded by rising sea levels, and melting glaciers.

2.3.2 Floods and drought

Warmer average global temperatures mean greater evaporation, with a warmer atmosphere able to hold more moisture aloft that can fall as precipitation, increasing the potential for flooding. There are a number of factors that contribute to flood risks implied by a warmer climate, including:

- more frequent wet spells in middle/ high latitude winters;
- more intense mid-latitude storms;
- increased frequency of extreme precipitation events;
- increased magnitudes of precipitation events of high intensity; and
- land use changes and surface degradation (for example, deforestation and urbanisation)[8].

The combination of more intense and frequent storms with land use changes is already proving to be deadly for the world's vulnerable populations. In 2004, a tropical storm that killed 18 people in the Dominican Republic resulted in the deaths of 3000 people across the border in

(8) "Climate Changes the Water Rules: how water managers can cope with tomorrow's climate change", p. 23 http://www.waterandclimate.org/report.htm

Haiti; the difference has been attributed to deforestation, and the destruction of mangrove forests that are essential to coastal defence. Moreover, in South East Asia, areas with healthy mangrove and tree cover were significantly less likely to have experienced major damage as a result of the 2004 tsunami.[9]

In drier regions, however, even a slight rise in temperatures will lead to greater loss of moisture, exacerbating drought and desertification. Drought will lead to decreased water availability and water quality for populations in many water-scarce regions, particularly in southern Africa, north Africa, Central America and central Asia.[10] When less precipitation and higher temperatures occur simultaneously, the availability of water resources is reduced even further while evaporation is increased, leading to a vicious cycle. [11] In Sub-Saharan Africa, for example, long periods of drought are becoming more common and are predicted to become more widespread. While some farmers have been able to survive by selecting seed varieties based on changing conditions, poorer farmers have not been as able to adapt.

2.3.3 Rising sea levels

Melting of ice (see *Section 2.3.4*) and thermal expansion of oceans as a result of increased average temperatures will result in rising sea levels. Sea levels have already risen between 10-20 cm over pre-industrial averages and are expected to rise further by up to one metre during the 21 Century.[12] Changes in sea level will increase coastal erosion, and flooding of wetlands and lowlands. It will also have a significant impact on the availability of freshwater:

- groundwater resources in coastal plains are potentially vulnerable to salinisation from rising sea levels, due to their low elevation and hydraulic gradient;
- salt water intrusion in the lower reaches of the deltas will be exacerbated by predicted rises in sea levels; and
- reduced protective capacity from extreme storms and floods, as higher sea levels provide a higher base for storm surges. [13]

2.3.4 Melting glaciers

Scientists are especially concerned about the Arctic, where the effects of climate change are being felt more quickly and severely than anywhere else on the planet. Arctic temperatures increased by about 5 degrees during the 20th Century – 10 times faster than the global average. Snow cover has declined by some 10 percent in the mid-high latitudes of the Northern Hemisphere since the late 1960s and, in the Russian Arctic, buildings are collapsing because of thawing permafrost under the foundations.

The dramatic changes occurring in the Arctic are being felt around the world: melting glaciers contribute to rising sea levels, and also increased flash floods as river basins fill more quickly and with a greater volume of water, with the resulting impacts on freshwater availability. During dry seasons, water supplies are dramatically reduced due to reduced availability of glacial melt to fill streams and rivers.

(9) Secretariat of the Convention on Biological Diversity, 2006
(10) Smith, D.M. Just One Planet: Poverty, Justice and Climate Change. UK: Practical Action Publishing, 2006 p.21
(11) "Climate Changes the Water Rules", p. 23
(12) IPCC, "Climate Change 2001: Impacts, Adaptation and Vulnerability" (2001) www.ipcc.ch
(13) "Climate Changes the Water Rules" p. 18-19

Furthermore, thawing permafrost in the Arctic is releasing methane, a gas which has a very high global warming impact. This will act as a further feedback mechanism, accelerating ongoing climate change.

3 CLIMATE CHANGE AND THE POOR

3.1 OVERVIEW

Climate change is having, and will continue to have, the greatest impact upon the lives of the poor in developing countries. Most developing countries are in tropical or arid regions, which will experience climate change sooner and on a greater magnitude than temperate regions.

Further, the poor tend to be more vulnerable to the impacts of climate change. The poor are generally forced to inhabit land (floodplains, steep unstable slopes or exposed coastlines) that increases their exposure to climate risks. Developing countries also tend to be very reliant on climate-sensitive natural resources, such as agriculture, and have limited capacity to withstand and recover from the resulting storms, floods, droughts, disease outbreaks, and disruptions to food and water supplies as a result of climate change.

3.2 IMPACT OF CLIMATE CHANGE ON THE MDGS

Climate change will compromise development spending, and hence effective progress towards achievement of the Millennium Development Goals (MDGs, see *Box 3.1*). Official Development Assistance (ODA) is expected to increase by up to US $50 billion by 2010, as governments and international actors seek to reduce poverty in developing countries. The OECD estimates that in six countries alone, climate change could undermine US $1.5 billion in development assistance. [14]

Table 3.1 ODA at risk from climate change in six countries

Country	ODA at risk from Climate Change
Egypt	0.5 billion
Uruguay	3.8 – 5.6 million
Nepal	175 – 260 million
Fiji	6.9 – 10.8 million
Tanzania	0.12 – 0.25 billion
Bangladesh	0.22-0.53 billion
Source: OECD, see Footnote	

(14) OECD statistics, http://www.oecd.org/dataoecd/0/41/35842562.pdf

Box 3.1 Examples of the impact of climate change on the MDGs

- MDG1 (Poverty): Increase in temperature in India could reduce farm net revenues by 9- 25 percent;
- MDG2 (Education): In Bihar India, annual flooding shuts schools across the state for 3 months;
- MDG3 (Gender): 90 percent of victims in the 1991 Bangladesh cyclone were women and children;
- MDG 4,5,6 (Health): Incidence of Cholera increased 6-fold in Nicaragua following flooding as a result of Hurricane Mitch;
- MDG7 (Environment, including water resources): Total available water in Africa's large catchment basins of Niger, Lake Chad and Senegal, has already decreased by 40-60 percent.

Source: Adapted from Multi-donor report, "Poverty and Climate Change: Reducing the vulnerability of the poor through adaptation", http://www.eldis.org/static/DOC11253.htm

As explained in 'Just One Planet', "The nexus between climate change and poverty imperils the MDGs. In a warmer world, extreme poverty will be harder to beat, the incomes of the poorest will shrink not grow, education will fall further out of reach for poor families, disease will increase not decline and investment in safe water and sanitation will get riskier."[15]

A major factor in the reduced adaptive capacity of developing countries is the projected increase in the frequency and severity of extreme weather events and natural disasters. Over two thirds of disasters are already climate-related, and these have the greatest impact on the LDCs, with 94 percent of natural disaster-related deaths occurring in developing countries.[16] Worldwide, 25 million people have already been displaced by natural disasters and environmental degradation, and this is estimated to increase to 50 million by 2010 and 200 million by the 2080s.[17] As these events become more severe, they pose a substantial risk to ODA and effective poverty reduction. In the period between the 1970s and 1990s, economic losses reported as a result of natural disasters increased five-fold, from US $131 billion to $629 billion. During that same period, the number of reported disasters also rose by three times, from 1 110 to 2 742.[18]

(15) Smith, D.M. Just One Planet: Poverty, Justice and Climate Change. UK: Practical Action Publishing, 2006 p.27
(16) "An Adaptation Mosaic: a sample of the emerging World Bank work in climate change adaptation", The World Bank (February 2004)
(17) Smith, D.M. Just One Planet: Poverty, Justice and Climate Change. UK: Practical Action Publishing, 2006 p.71
(18)"Up in Smoke: Threats from, and responses to, the impact of global warming on human development", Working Group on Climate Change and Development reports (October 2004)

- Hurricane Mitch destroyed ¾ of Honduras' GDP, and set back development by 20 years
- 1998 flood in Bangladesh: losses of £3 billion, equivalent to 8 percent of country's GDP
- 1991/92 drought in Africa contracted real income by amounts ranging from 2-8 percent
- According to UNEP, economic losses due to natural disasters are doubling every 10 years

Source: NEF (2001), "The End of Development?" http://www.neweconomics.org/gen/uploads/e_o_d.pdf

Box 3.2 Examples of the costs of disasters

3.3 IMPACT OF CLIMATE CHANGE ON WATER RESOURCES FOR HUMAN DEVELOPMENT

Access to water plays a key role in development – it sustains human life, both through direct consumption and use in agriculture (for food security) and industrial activities. While water availability for drinking purposes is essential, it cannot be separated from wider water resource management issues. Its use for industrial purposes is important to fuel economic growth, and competing demands from households, agriculture and industry can cause conflict over water availability and use. Today, more than one billion people still lack access to safe water, while over two billion lack safe sanitation. [19]

- Hurricane Mitch destroyed ¾ of Honduras' GDP, and set back development by 20 years
- 1998 flood in Bangladesh: losses of £3 billion, equivalent to 8 percent of country's GDP
- 1991/92 drought in Africa contracted real income by amounts ranging from 2-8 percent
- According to UNEP, economic losses due to natural disasters are doubling every 10 years

Source: NEF (2001), "The End of Development?" http://www.neweconomics.org/gen/uploads/e_o_d.pdf

The changes to the hydrological cycle (*Section 2.3*) will deteriorate the availability of water for human populations, in terms of quantity, quality and accessibility of water supplies. These conditions will be further exacerbated by increasing natural disasters and their impacts on water for human populations.

3.3.1 Changes in the quantity, quality and accessibility of water supplies

Quantity of water

Many of the world's countries already struggle under existing water stress from pressures such as irrigation demands, industrial pollution and water borne sewerage. These pressures will be significantly exacerbated by climate change, which for many regions will result in reduced rainfall and increasing temperatures, further reducing the availability of water for drinking, household use, agriculture and industry. As these competing demands intensify under climate change,

(19) "Climate Changes the Water Rules", p. 26

effective governance for balancing water demands will become essential, particularly in the face of strong pressures to prioritise industrial uses over other uses such as drinking supplies.

The Stockholm Environment Institute estimates that, based on only a moderate climate change, by 2025 the proportion of the world's population living in countries of significant water stress will increase from approximately 34 percent (in 1995) to 63 percent.[20]

For example, in Africa's large catchment basins of Niger, Lake Chad and Senegal, the total available water has already decreased by 40-60 percent, and desertification has been aggravated by lower than average annual rainfall, runoff and soil moisture, especially in Northern, Southern and Western Africa.[21] The consequences for water supply include smaller flows in springs and rivers, and decreasing groundwater levels.

Quality of water

The quality of existing water supplies will become a further concern in some regions of the globe. Water acquires most of its geochemical and biochemical substance during its cycle from clouds to rivers, through the biosphere, soils and geological layers. Changes in the amounts or patterns of precipitation will change the route/ residence time of water in the watershed, thereby affecting its quality. As a result, regardless of quantity, water could become unsuitable as a resource if newly-acquired qualities make it unfit for the required use.[22] For example, in areas with relatively high water tables, or under intensive irrigation, increased evaporation due to higher temperatures will raise the concentration of dissolved salts. Further, increased flooding could raise water tables to the point where agrochemicals/ industrial wastes from soil leach into the groundwater supply.

Likewise, higher ocean levels will lead to salt water intrusion in coastal groundwater supplies, threatening the quality and quantity of freshwater access to large populations. Exacerbated by over-abstraction of groundwater inland, this is already occurring in Israel and Thailand, in small islands in the Pacific and Indian Oceans and the Caribbean Sea, as well as in some of the world's most productive deltas, such as China's Yangtze Delta and Vietnam's Mekong Delta.

Accessibility of water

As (seasonal) water quantities and quality decrease as a result of intensification of the hydrological cycle, competition for available resources will intensify. Demand for agricultural and domestic water in particular increases significantly at hotter and drier times of the year. Agriculture has always been the dominant end-use of diverted water; this will only intensify with increasing needs for irrigation brought on by higher temperatures and reduced precipitation, coupled with increasing populations. Meanwhile, demands of industry are expected to become a greater issue in the competition for dwindling resources; in the event of decreasing water tables as a result of climate change, industrial needs will be forced to compete with agricultural and domestic water supply sources, and could lead to conflict.

(20)"Up in Smoke: Threats from, and responses to, the impact of global warming on human development", Working Group on Climate Change and Development reports (October 2004)
(21) UNFCCC
(22) "Climate Changes the Water Rules" p. 16-17

3.3.2 Natural disasters

The increase in natural disasters, primarily floods and droughts, will further exacerbate issues over water availability and water quality.

Of particular concern are increased risks from flooding. The Intergovernmental Panel on Climate Change (IPCC) has projected that flooding and landslides pose the most widespread direct risk to human settlements from climate change.[23] The UNFCCC predicts that "a future of more severe storms and floods along the world's increasingly crowded coastlines is likely, and will be a bad combination even under the minimum scenarios forecast".[24] Beyond the immediate and apparent devastation caused by flooding, including loss of life and livelihoods, flooding has major impacts on water resources, and hence humans:

- overburdening of wastewater and sewer systems, leading to contamination of water supplies with subsequent outbreaks of dysentery and cholera;
- disruption of safe water supplies through damage to infrastructure;
- flood water in low-lying areas creates breeding grounds for mosquitoes with increased risk of malaria, yellow fever and dengue;
- floods can increase the incidence of diseases such as skin diseases as a result of constant contact with water; and
- inadequate nutrition following disruption of income and food distribution systems. [25]

3.4 CONSEQUENCES FOR HUMAN POPULATIONS

3.4.1 Introduction

The predicted changes in quantity, quality and accessibility to water will have important consequences for human populations, through impacts to agriculture and food security, health, economic activity, and conflict over water resources.

3.4.2 Impacts to agriculture and food security

Agriculture will be one of the hardest-hit sectors by climate change, reinforcing the unequal distribution of impacts. In addition to pressures caused by population growth and intensified agriculture, warmer
temperatures will lead to increased water evaporation, intensifying the need for irrigation precisely as water becomes even less available. Shiklomonov (2003) predicts that water withdrawal for agriculture will rise from 2 600 km^3 in 2000 to 3 200 km^3 by 2025.[26]

Increasing supply for irrigation will simply not be feasible in many regions, particularly where irrigation capacity is not sufficiently developed to accommodate changing precipitation patterns. In sub-Saharan Africa, for example, where up to 90 percent of agriculture is rain fed, the sector accounts for 70 percent of employment and 35 percent of GNP, and changes in rainfall will have

(23) "Up In Smoke", p. 18
(24) UNFCCC
(25) "Climate Changes the Water Rules", p.35
(26) "Climate Changes the Water Rules" p. 27

a significant social and economic impact.[27] Meanwhile, it is estimated that a temperature increase of 2-3.5 degrees Celsius in India could result in a decline in farm revenues of between 9 and 25 percent.[28] The International Rice Research Institute, for example, estimates that for every degree Celsius of night time temperature increase, there is at least a 10 percent decrease in rice production for the African region.[29] While some areas will benefit from longer growing seasons (such as northern Asia), changes in water regimes will render other areas unsuitable for traditionally-grown products, and others areas will become susceptible to new forms of crop and livestock diseases. In regions already affected by food shortage and famine, this could cause further disruptions in food supply.

3.4.3 Health impacts

Clearly, the health implications of changes to water supply are far-reaching. Currently, more than 3 million people die each year from avoidable water-related disease,[30] most of whom are in developing countries. The effects of climate change on water will exacerbate the existing implications of water shortages on human health, as follows:

- Water-borne diseases: result from the contamination of water by human/ animal faeces, or by urine infected with pathogenic viruses/ bacteria, both of which are more likely to occur during periods of flood and therefore intensify with the projected increases in natural disasters under climate change. Diseases are transmitted directly when the water is drunk or used in food preparation.

- Water-washed diseases: those resulting from inadequate personal hygiene as a result of scarcity or inaccessibility of water (including many water-borne diseases and typhus).

- Water-based diseases: those caused by parasites that use intermediate hosts living in/ near water (e.g. guinea worm).

- Water-related diseases: borne by insect vectors that have habitats in/near water (such as malaria). For example, malaria has recently appeared in Nairobi and the highlands of Kenya, illustrating the expanding range of mosquitoes due to warmer temperatures.

- Water-dispersed diseases: infections for which the agents proliferate in fresh water and enter the human body through the respiratory tract (e.g. legionella).[31]

Further indirect health challenges include malnutrition arising from agricultural disruption and food insecurity.

(27) "Up In Smoke" p. 8
(28) "Up in Smoke"
(29) "Up In Smoke" p. 8
(30) "Climate Changes the Water Rules", p.26
(31) "Climate Changes the Water Rules" p. 33. Because the extent and severity of climate change remains uncertain, it is not possible to quantify the anticipated risks. This is one of the issues that makes climate change a particularly dangerous issue.

3.4.4 Decreases in economic activity

Water plays a key role in economic growth and hence development. Reductions in water quantity and quality will require people, particularly women and children, to spend increased time gathering water, detracting from employment and educational opportunities. A greater proportion of household income may need to be spent on water delivered from private sources, such as tankers, to supplement lack of water locally. Further, water is a key input to industrial uses, and decreases in water availability will reduce the amount of industry and hence inputs to the local economy.

3.4.5 Conflict over water resources

Changes to accessibility of water have the potential to increase conflict, as the competing demands of private, agricultural, and industrial uses for water put pressure on resources. This may exacerbate conflict in existing water stressed areas competing locally for access to natural springs and rivers, as well as lead to conflicts on a larger international trans-boundary scale. For example, in northern Kenya, the Samburu are having to cope with changing patterns of rainfall and reductions in rainfall amount, which coupled with other pressures on the natural resources are leading to increasing conflict among tribal groups over access to scarce water.[32] Whereas in Central Asia, reduced water availability for agriculture has increased tensions among the former Soviet states.

(32) Smith, D.M. Just One Planet: Poverty, Justice and Climate Change. UK: Practical Action Publishing, 2006 p.73

4 WHAT CAN BE DONE?

4.1 INTRODUCTION

There are two ways to manage the risks posed by climate change: mitigation of GHGs to slow or reverse the pace of climate change, and adaptation to climate impacts to minimise their effects.

4.2 MITIGATION

Mitigation implies the human measures, structural and non-structural, undertaken to limit the adverse impacts of climate change by reducing the levels of GHGs in the atmosphere. This is accomplished through the development of appropriate technology for reducing emissions and/ or capturing them at their source. Examples of mitigation include measures such as energy efficiency, promotion of renewable energy sources, and carbon trading.

Mitigation of GHGs is essential to slow and eventually reverse the impact of climate change. By seeking to limit these impacts, the severity and extent of which remain largely unknown, mitigation is the most cost-effective and least risky strategy for reducing the future effects of climate change.

4.3 ADAPTATION

4.3.1 Overview

The reality, however, is that climate change is already occurring; even if mitigation efforts were immediately able to reduce global carbon emissions to zero, there will be certain and ongoing impacts from climate change that need to be addressed. Adaptation describes a set of responses to the actual and potential impacts of climate change to moderate the harm or take advantage of the opportunities that climate change may bring.

This is a new, critical and urgent challenge. Climate change, as a subject, has been dominated by the natural science community and has thus been debated at a high level with an emphasis on national and international acceptance and, subsequently, mitigation. Now this top-down technical consideration of climate change needs to be met with a bottom-up community based approach. In fact the community based approach has to better inform policy and practice at the higher levels.

4.3.2 Adaptation and development

The poor prioritise risks associated with day-to-day survival, such as lack of income and poor health, over risks associated with future less familiar events. This focus on livelihoods then provides the natural entry point to engage with the poor and vulnerable to adapt to climate risk. Climate change adaptation can not simply be bolted on to development activities. It must be integrated within the development priorities of local people. A “no regrets” approach whereby adaptation provides short-term benefits, regardless of longer-term aims based on a changing climate, helps ensure initiatives are owned locally and sustainable over time.

Development can, by its very nature, build adaptive capacity. It can help poor countries to become less vulnerable to the impacts of climate change, by diversifying their economies and livelihoods, increasing access to markets, increasing access to education and healthcare and building social and financial safety nets. This is why targeted development of natural, physical and human capacity is essential, including, for example, investing in water catchment infrastructure, or tailoring farm management practices to projected climate variability.

Adaptive capacity is also about creating the local information and conditions that are needed to support adaptation. While public awareness of climate change is increasing in the North, in most developing countries public awareness is very low. Efforts to alert vulnerable people and communities to the dangers presented by climate change are necessary to establish an understanding of the risks involved, and to make use of local capacities to build adaptability.

Adaptation should therefore be based on an understanding of local livelihoods, over-laid with an understanding of climate risks and how they impact these livelihoods.

4.3.3 Mal-adaptation

Not all development activities will be beneficial for reducing vulnerability to climate change. Mal-adaptation refers to situations in which vulnerability to climate change is increased through current development paths. It is commonly caused by a lack of information, or awareness of the potential effects of development policies on other development objectives or sectors, combined with political decision making which focuses on short term goals rather than long term planning.

Agricultural interventions through research, extension or marketing policies can have unintentionally negative impacts on poor farmers, particularly in areas that experience opposing extremes in climate.

For example, agricultural production in tropical Asia is susceptible to both increasing temperatures and changing monsoon patterns. Consequently, increasing leaf surface temperatures would have a significant impact on crop metabolism and yields; however, it may also make crops more sensitive to moisture stress.

Source: IPCC, Climate Change 2001: Impacts, Adaptation and Vulnerability

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Box 4.1 Agricultural mal-adaptation in tropical Asia

Sustainable water and sanitation projects are characterised by a demand responsive approach and cost recovery, and are delivered within a partnership framework that integrates water resources management. However, in some situations it may be necessary to work outside of that framework, such as in cases of informal settlements or refugee situations. In those instances, short-term work that is unlikely to provide long-term sustainability might be more suitable, if supported by advocacy on the causes of the situation

4.3.4 The economic argument for adaptation

Funding for adaptation initiatives in developing countries will continue to be a challenge. However, current evidence suggests that the benefits of many adaptation options validate their costs. For example, practitioners of disaster management acknowledge that it is typically more cost effective to invest in disaster risk reduction measures to reduce the impact of a disaster, than it is to provide emergency and recovery relief once the disaster has taken place (see *Box 4.2*).

Box 4.2 Examples of cost effectiveness of disaster risk reduction

- *China*: $3.15billion spent on flood control between 1960 and 2000 is estimated to have averted losses of some $12billion.
- *Brazil*: Rio flood reconstruction and prevention project yielded an internal rate of return exceeding 50 percent.
- *India*: Disaster mitigation and preparedness programmes in Andhra Pradesh yielded a benefit/cost ratio of 13.38.
- *Vietnam*: Mangrove-planting project aimed at protecting coastal populations from typhoons and storms yielded an estimated benefit/cost ratio of 52 over the period 1994 to 2001.

Source: The Stern Review

4.4 *APPROACHES TO ADAPTATION*

4.4.1 Overview

Broadly speaking, the approach to adaptation requires a series of steps, all of which need to be integrated into more general development planning, and include community participation throughout:

- climate risk screening and assessment;
- identification of risk reduction measures;
- identification of priorities for action (using tools such as participatory community risk assessment, and economic analysis of the costs and benefits of adaptation options);
- making the case for implementation of adaptation measures; and
- associated awareness-raising and capacity building to support adaptation responses.

In particular, two approaches to strengthen adaptation are particularly relevant to an international development agency and its partners: community level adaptation, and advocacy on adaptation.

4.4.2 Community level adaptation

Participatory risk assessment can provide the ideal means by which adaptation measures can be integrated within development activities such that lives and livelihoods are resilient and sustainable in the face of the range of risks they are exposed to, including risks associated with climate change. The process of undertaking a well-facilitated risk assessment will raise awareness of the implications of climate change, and provide an opportunity for these to be discussed and debated. Ideas for developing means to adapt should emerge and, if the process is fully participatory in nature involving key local stakeholders, these ideas stand a stronger chance of being sustainable than external solutions. Local government officials and representatives of the private sector should be among the local stakeholders involved in the risk assessment and adaptation planning process. Shared development goals need to be determined if adaptation is to be sustainable.

Community level adaptation measures can be *structural* or *non-structural*. [33] The raising of hand-pumps above expected flood levels is a structural example. Awareness-raising of the risks associated with climate change is a non-structural example. However, the two methods are connected. Adaptation strategies are only as strong as the weakest link in a chain. [34] For instance, without awareness of the flood risks, the imperative for investing in building a raised platform will be lost.

Historically, the focus has been on structural measures. For example, with regard to flooding, traditionally methods have been dominated by top-down structural methods that attempt to control the flood, such as the building of embankments. In light of failures in this approach, in recent years there has developed a growing consensus that the preferred approach should be based on "living with floods". These focus upon the positive benefits of the natural flood process and encourage more appropriate land-use planning in the vicinity of flood plains.

4.4.3 Advocacy on adaptation

While the effects of climate change are experienced most acutely at a local level and in the poorest areas, the root causes of vulnerability to climate change are often far beyond local community control. Advocacy on climate change risk and vulnerability reduction, at all levels of government, is essential.[35]

Advocacy is necessary in the following areas:

- *Integration of climate risk into development planning through Poverty Reduction Strategy Papers (PRSPs) etc:* Climate change has implications across the breadth of sectors (health, education, agriculture etc) and levels (local, provincial, national and international) and is not only an environment issue. It is thus a subject that must influence all development decisions. Based on this understanding, work is required to ensure that *Poverty Reduction Strategy Papers (PRSPs)* and other mechanisms and structures that dictate paths of development take climate change into account. NGOs can play a key role in this agenda.

- *Integrating local perspectives into national planning on climate change:* At a national level, under the UNFCCC, government priorities for climate adaptation in many of the world's poorest countries are being outlined through the *National Adaptation Programmes of Action* (NAPA). The NAPA takes into account existing coping strategies at the grassroots level, and builds upon that to identify priority activities, rather than focusing on scenario-based modelling to assess future vulnerability and long-term policy at state level. In the NAPA process, prominence is given to community-level input as an important source of information, recognising that grassroots communities are the main

(33) *Structural measures* refer to any physical construction to reduce or avoid possible impacts of hazards, which include engineering measures and construction of hazard-resistant and protective structures and infrastructure.
Non-structural measures refer to policies, awareness, knowledge development, public commitment, and methods and operating practices, including participatory mechanisms and the provision of information, which can reduce risk and related impacts .(UN/ISDR terminology on disaster risk reduction)
(34) *Personal Communication, Ian Davis, Cranfield University, 2006.*
(35) See, for example, Tearfund's work Dried up, Drowned out: Perspectives from the developing world on a changing climate (http://tilz.tearfund.org/Research/Climate+change+and+disasters+policy/) and WWF's Climate Witness Programme (www.panda.org/about_wwf/what_we_do/climate_change/news/witnesses/index.cfm)

stakeholders. [36] There is therefore an opportunity to engage in this and ensure that plans are appropriate for the needs of the poor.

- *Supporting NGO Coalitions for climate change:* Isolated groups and organisations will struggle to make their voice heard at a national and international level. Therefore, within national boundaries, coalitions should be formed or joined, along the lines of the UK Working Group on Climate Change and Development, so as to help deliver strong, coherent and effective messages to decision-makers.

4.4.4 Approaches to adaptation and water

Overview

The adaptation measures appropriate at the community level for reducing vulnerability to changing water regimes are, in essence, no different from good practice sustainable development and disaster risk reduction. The challenge lies in introducing such measures in areas where people are currently unaccustomed to the new risks associated with climate change, and on a scale that befits the problem. This calls for a change in perspective for all involved as traditional knowledge is only suitable for traditional problems.

It is necessary to consider what impact less predictable rainfall patterns, more frequent droughts, and weather hazards of unprecedented intensity will have on the water quantity, quality and accessibility for communities. Community-based adaptation options will vary depending upon circumstances and need to be based on local decision-making.

Adaptation measures include some of the following institutional, educational and project design changes.

Institutional

- *Local watershed management*. Support institutions that have the authority to manage the local catchment in the interest of all stakeholders, including domestic water users; ensure there is proper accountability in these institutions.
- *Right to Water.* Clarify the legal entitlement to access water resources for all users.
- *Data & Information.* Promote greater collaboration in data-collection, monitoring and access to national information.

Educational

- *Awareness-raising:* Build local understanding on the links between predicted climate change and the impacts that this will have on water resources at a local level.
- *Health education*: related to increases in climate/water related health issues
- *Household water conservation* to encourage people to use grey water for washing, bathing and watering gardens and livestock to preserve safe drinking water supplies.

(36) http://unfccc.int/adaptation/napas/items/2679.php

Project design

- *Use of contour bunding, gully plugging, and check dams and dykes* to catch rainwater and give it time to soak into the ground (reduce runoff), lifting water tables and hence availability of drinking water.
- *Rainwater harvesting (i.e. from rooftops) and tanks:* to store rain water as an alternative source of drinking water so that communities aren't solely reliant on groundwater.
- *Community ponds:* to irrigate surrounding land, provide a water source and options for fish cultivation.
- *Alternative cropping patterns:* Use of drought resistant crops which require less water input and hence have less impact on water tables.
- *Raised hand-pumps:* to protect drinking water from flood contamination.

Contour bunding involves constructing low mounds, embankments or bunds' of earth or stones along the contour of a field to catch the rain when it falls so that it has time to soak into the ground rather than run off and be lost. The bunds may be planted with vegetation to help fix them, as well as to help delay the rainwater. A number of bunds may be spaced at intervals across the field or, if the field is small, only along the lowest edge. The bunds can also help prevent valuable soil being washed away.

Gully plugging – the placing of piles of stones across a gulley – can prevent gullies caused by heavy tropical rains getting worse and even help 'cure' them as soil builds up behind the 'plug'.

Check dams are small, stone or concrete dams usually constructed across watercourses and also designed to delay the flow of rainwater so it has time to soak into the earth and replenish the groundwater table while keeping adjacent land moist.

Tanks – in India and elsewhere larger dams or bunds were traditionally built to create ponds or 'tanks' to store water. Water seeps from these ponds into fields of crops and every so often the pond is de-silted and the silt used as a fertiliser. Although there has been a decline in these ponds, there are some places where they are being revived.

Source: New Economics Foundation, 2004, "Up in Smoke", http://www.neweconomics.org/gen/z_sys_publicationdetail.aspx?pid=196

Box 4.3 Further detail on adaptation measures from "Up in Smoke"

4.5 CAMPAIGNS ON CLIMATE CHANGE

A variety of campaigns to address the risks from climate change are active globally and in the UK. The following list provides brief details on some of these campaigns, with web links for further reference.

- *UK Working Group on Climate Change and Development.* The Group was initiated by IIED and the New Economics Foundation, in recognition of the need to involve development organisations in the climate debate. The Working Group's unique selling point is that it shows how climate change is of equal concern to both environment and development agencies. Working Group members include ActionAid, Christian Aid, the Catholic Institute for International Relations, Friends of the Earth, Greenpeace, IIED, ITDG, nef, Oxfam, People and Planet, RSPB, Tearfund, Water Aid, World Vision and WWF. (http://www.iied.org/CC/projects/workinggroup.html)

- *Stop Climate Chaos.* A coalition of environmental and international development organisations, as well as women's organisations, activist groups and faith-based campaigns, which 'aims to build irresistible popular pressure on politicians to act' (www.stopclimatechaos.org.uk)

- *The Climate Action Network.* A global network of over 287 NGOs, working 'to promote government and individual action to limit human-induced climate change to ecologically sustainable levels' (www.climatenetwork.org)

- *Linking Climate Adaptation Network.* The objective of the Linking Climate Adaptation (LCA) Network is to help communities, policy-makers, practitioners and academics share experiences and knowledge about adaptation to climate change. (www.eldis.org/climate/adaptation/organisations/index.htm)

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