Global Climate Change, Human Security, and Democracy

Overview of Core Issues

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Introduction

The UNDP's 1994 Human Development Report defines human security to include threats in seven areas: economic security, food security, health security, environmental security, personal security, community security, and political security. The UNDP definition of environmental security can also be interpreted to include water security, climate security, and ecosystem (services) security. In turn, threats to human security threaten human rights. **Climate change is already challenging the realization of a broad range of internationally protected human rights**, such as rights to food, water, environment, health, shelter, property, and education; rights associated with livelihood and culture; with migration and resettlement; with democratization and self-determination; political and social stability; and with personal security in the event of crime and conflict.

However, the interrelations between climate change, human security and human rights are very complex. The worst effects of climate change are likely to be experienced by those individuals and groups whose rights protections are already challenged or lacking. In part, this is a coincidence since the greatest impacts of climate change are occurring and will likely continue to occur in the world's poorest nations, where rights protections are often weak. Nevertheless, this effect is also causal and mutually reinforcing. Populations whose rights are inadequately protected are likely to be ill-equipped to understand or prepare for climate change impacts; less able to lobby effectively for social, government, or international action; and more likely to lack the resources necessary to adapt to climate-related changes in their environmental and economic contexts. Therefore, a complicated cycle relates inadequate access to natural resources, poor infrastructure, weak rights protections, and vulnerability to climate change-related impacts.

There is also an economic relation between climate change, security, and human rights vulnerability. Rights protections are often weak in resource-poor situations. Resource scarcity also limits the capacity to respond and adapt to climate change. Where governments are poorly resourced, climate change effects will likely impact populations unevenly and unequally in ways that are discriminatory, because the private capacity of individuals to persist and adapt differs greatly.

The creation of an international climate change regime also has human rights implications. Mitigation policies have clear human rights implications. Any set of strategies that operate at global level will likely determine the long-term access that millions of people will have to basic public goods. Furthermore, short-term strategies (e.g., energy policy, whether and where to produce biofuel crops, forest conservation) will affect food, water, health, environmental, and economic security and, consequently, the livelihoods and cultures of many people.

Adaptation policies will also have human rights implications. In the context of human rights, adaptation may be reframed as a corrective or compensatory response to potential or actual climate change-related human rights violations. Before or during climate change impacts, adaption can reduce the likelihood that rights violations would result from those impacts. Adaptation actions taken after climate change impacts occur may also compensate where violations have already occurred. However, adaptation responses can also negatively affect human rights – e.g., if communities or individuals are expected to conform to new economic policy imperatives, or if they are forcibly relocated from impacted areas,

In terms of governance, failure to act (e.g., mitigation, adaptation, relief aid) adequately to climate change impacts can also threaten human rights, particularly in poor nations and in authoritarian or unstable regimes. As climate change adversely impacts human security and governments' capacities to support their populations, more authoritarian regimes may develop in order to maintain legitimacy and political and socioeconomic control. This may be a particular concern where crisis and a breakdown of the environment and society occurs, along with a complex combination of generalized upheaval, human insecurity and social dislocation, causing governments to apply emergency measures, austere or radical political and economic reform, and expand control (e.g., rationing, nationalization, privatization) over public resources.

Despite the obvious interdependent issues discussed above, **until recently, mainstream climate change literature and debate has given little attention to human rights concerns**. The interdisciplinary nature of climate change and other environmental issues may be one reason for why climate change analyses have not considered human rights concerns. For example, climate change began as a scientific discipline that eventually developed into the social and economic fields. **Although a "human rights approach" would assist framing research interests and the formation of effective policies to address climate change, there are several reasons why such an approach may be challenged:**

Human rights are difficult to enforce. Climate change generally affects categories of human rights that have weak enforcement mechanisms under international law. Additionally, rights that have strong protections may not be subject to normal enforcement procedures, because the impacts caused by climate change can be generally attributed only indirectly to the identified perpetrators.

Extraterritorial responsibility is difficult to establish, since under human rights law government generally has the primary duty to act on behalf of individuals when rights are violated. The responsibility for climate change impacts, especially in the most vulnerable nations, frequently lies with diffuse actors who are often located across international borders.

Local accountability is hard to establish. Although poorer nations tend to contribute less to climate change than more wealthy nations, they are most likely to suffer from the impacts of climate change. If a government cannot be held accountable for failing to protect the human rights of its population in ordinary circumstances, it will be even more difficult to hold it responsible for circumstances it did not create.

Emergency conditions limit the application of human rights law. In the event that climate change impacts are severe or catastrophic, a government may declare an emergency in response to human security concerns or to contain social unrest or internal socioeconomic disruptions. International human rights treaties and many national constitutions allow for the derogation of many human rights in times of emergency. Emergency regimes are often critical or dismissive of human rights constraints. Since governments are empowered to act expediently, they may act with less regard to individual rights and interests that might prevent achieving the greater good, political or economic reform (e.g., disaster capitalism), consolidation of power, and/or regime change.

Rights may conflict with the rights of others. Human rights can protect others besides those who are may be impacted by climate change. For instance, economic actors are also rights-holders, and it is likely (and already occurring) that some of them will invoke the human right to property or peaceful enjoyment of

their possessions to impede or prevent progressive action on climate change. Other human rights claims (e.g., rights to culture, freedom of religion) may also be in conflict with climate change policies. **Furthermore, a definitional problem arises between individual human rights and collective rights** (including communal and "future-generation" rights). Climate and emergency policies will necessarily produce choices about the distribution of costs and benefits, which may limit some or all of these rights for the public good or for political or economic gain. Such policies will likely create struggles over what rights can be constrained, for what purpose, and for the benefit of whom.

In the context of this project – i.e., global climate change, human security, and human rights and democracy – **it will be important to consider these five human rights approach challenges in the context of the complex interdependent relations between climate change, human security and human rights**.

The lists in the following sections describe: (1) core issues related to climate change, security, and human rights; (2) relevant and important associated issues; and (3) a brief analysis of regional issues. The core issues can be both causal and consequential issues pertaining to the human security and rights impacts of climate change, since these core issues are complex systems that feedback into and influence one another. For example, climate change could cause ecosystem and water stress in a region, which could lead to food and economic insecurity for the local population. Consequently, people displaced by this water and food scarcity, and any associated crime or conflict, might migrate to another area, which may cause an increased stress on water, food, and economic resources in the destination area. This stress may provoke crime, conflict, and further displacement among the migrant and original population of the destination area. Therefore, these interdependent core issues should be thought of as lenses through which to frame and understand climate change impacts on human security and rights issues. Ultimately, all of these core issues will have similar impacts on human security while challenging the realization of a broad range of human rights, such as rights to food, water, health, property, livelihood, culture, self-determination, and personal security.

Migration and Displacement

Environmental degradation and disasters can cause migration, and the movement of people can also have significant effects on surrounding ecosystems. Migration can also have significant socioeconomic and environmental impacts for the areas of origin, areas of destination, and the migratory routes in between. As an adaptation strategy to climate and environmental change, migration is an essential component of the socio-environmental interactions that needs to be assessed and managed. These complex relationships need to be addressed in an interdisciplinary manner, by taking into account other possible factors including human and economic development, trade, ecosystem services, livelihood strategies, human security, and conflict. Therefore, **it is important to address the connections between the environment and climate change, and human settlement and population movement from a perspective of human mobility**.

The scale of migration flows, both internal and cross-border, will likely increase due to accelerated climate change, which will have unprecedented impacts on lives, livelihoods, and supporting ecosystems. Such migration can positively and negatively effect both the local coping and environmental capacities in areas from which these migrants originate, as well as their temporary or permanent destinations. Gradual and sudden environmental changes are already causing significant population movements. The number of storms, droughts and floods increased threefold over the last 30 years with devastating effects on vulnerable communities, especially in the developing world. In 2008, 20 million persons were displaced by extreme weather events, compared to 4.6 million internally displaced by conflict and violence over the same period. Although extreme and sudden environmental changes can be devastating, gradual changes in the environment tend to have a greater impact on the movement of people than extreme events. By 2050, future forecasts predict that 200 million environmental migrants (within a range of 25 – 1,000 million) will move either within their countries or across borders on a permanent or temporary basis. This figure is the same as the current estimate of international migrants worldwide.

Migration and displacement are both responses to and a causal issue in the climate change, security, and human rights concerns of this project. For instance, an influx of environmental migrants from an area suffering from food and water stress may further stress the food and water resources of the destination area. Competition over scarce resources and other socioeconomic issues may result in a declining quality of life and conflict, which may cause people to migrate to a new destination, thereby perpetuating the cycle of migration and displacement. Additionally, such situations would likely challenge governance systems, security, and human rights as socioeconomic and ecological systems become stressed.

Ecosystems and Biodiversity

Ecosystems are components of biodiversity; and species and their diversity are essential components within ecosystems. Each species, and therefore biodiversity, has a fundamental role in the provision of ecosystem services (*see Appendix 1*). **The loss of biodiversity will lead to a change in the services provided by an ecosystem, which can have a direct and significant structural impact with human, social and economic costs.** The extent and rate of changes to ecosystem services depend on many factors such as: the abundance of species and biomass; the quality and structure of habitats and ecosystems; the level of species diversity; and human activities. Ecosystem degradation can also contribute to climate change. For instance, deforestation is a major contributor to climate change. Therefore, ecosystems and their biodiversity are the foundation of the global economy and human well-being; and they need to be valued and protected.

Degradation and damage to global ecosystem services and biodiversity is acute and accelerating. In the last century, 35% of mangroves, 40% of forests and 50% of wetlands have been lost. In the past fifty years, 60% of ecosystem services have been degraded. Eighty percent of global fisheries are fully- or over-exploited. Species loss is 100 – 1,000 times than in previous geological times as a result of human activities. Climate change will increase the rate of species loss. Furthermore, critical thresholds for ecological sustainability are being passed. For example, coral reefs risk collapse due to global warming and ocean acidification, if GHG emissions are not urgently reduced.

In addition to human activities, global ecosystems have already been affected by climate change. Approximately 20 – 30% of species assessed by the IPCC may be at risk of extinction from climate change impacts within the 21st century, if global mean temperatures exceed 2 – 3 °C relative to pre-industrial levels. Currently, the planet is experiencing a mass extinction event – called the 'Sixth Extinction" or "Holocene extinction" – comparable to the five mass extinctions in the history of life on earth. Four of these mass extinction events occurred in the last 3.5 billion years in which many species disappeared in a relatively short period of geological time. The most recent of these events was the Cretaceous–Tertiary extinction event 65 million years ago, which is best known for having eliminated the non-avian dinosaurs and many other species. All of these extinction events were associated with global-scale climate changes.

Ecosystem damage carries costs for business, economies, and society. Ecosystem services provide climate regulation, water resources, food security, materials, energy resources, and are the foundation for much economic activity. Increasing demand from growing population and wealth is a key cause of biodiversity loss. However, economic signals from policy and market prices fail to reflect the true value of biodiversity. And, conflicts and humanitarian crises often times are directly or indirectly related to ecosystem degradation.

Therefore, understanding ecosystem and biodiversity value is critical to inform decision-making on land and water use, food and natural resource production (e.g., timber, fiber, medicine), and ecosystem management. The economic and human security costs of acting to sustain biodiversity and ecosystem services can be substantially less than the cost of inaction. Investing in ecologically integrated infrastructure and development can offer greater returns than conventional mainstream alternatives. Such investment can also help alleviate poverty, improve human rights, and address commitments under the Millennium Development Goals. **Ultimately, protecting ecosystems and the species within them, and integrating sustainable development with ecosystems, will help promote human security and rights by**

helping to protect the natural resources and ecosystem services on which the lives and livelihoods of individuals and communities depend.

Water

Climate change will alter the distribution of precipitation and water resources throughout the world. In particular, high latitude regions, such as the Arctic nations, will likely receive more precipitation and experience more flooding events. Conversely, some temperate and arid regions will generally receive less precipitation. Declining snowpacks, glaciers, and ice sheets will decrease the amount of perennial runoff while increasing flood risks. Salt water contamination of freshwater aquifers in coastal areas will occur due to sea level rise. Table 1 in *Appendix 2* shows projected major water resource trends and impacts due to changes in climate and extreme weather events during the 21st century.

Water demand has been increasing at more than twice the rate of population grow in the last century. The world's more than 6 billion people are appropriating about 54% of all the accessible freshwater contained in rivers, lakes and underground aquifers. Over 1.4 billion people currently live in river basins where the use of water exceeds minimum recharge levels, which results in the drying of rivers and depletion of groundwater. By 2025, water withdrawals may increase by 50% in developing countries, and by 18% in developed countries. By 2025, 1.8 billion people will also be living in countries or regions with absolute water scarcity, and two-thirds of the world population could live under water stress conditions.

The daily drinking water requirement per person is 2 – 4 liters, but it requires 2,000 – 5,000 liters of water to produce one person's daily food. Each person needs 20 – 50 liters of safe freshwater a day to ensure her basic needs for drinking, cooking and cleaning. However, more than one in six people worldwide – over 1 billion – do not have access to even this amount of safe freshwater. **Currently, 2.5 billion people – including almost one billion children – live with unsafe drinking water and without basic sanitation.** Approximately 1.5 million children per year die as a result of poor sanitation.

In 2007, the estimated number of undernourished people worldwide was 923 million. **By 2050, global water resources will need to support the agricultural systems that will feed and create livelihoods for a projected additional 2.7 billion people.** Of the world's total use of freshwater about 70% is used for irrigation, about 22% is used for industry, and about 8% is used for domestic use. Irrigation increases the yields of most crops by 100 – 400%, and irrigated agriculture currently supplies 40% of the world's food production. Approximately 20% of all cropland is irrigated in the world. Rainfed agriculture is practiced on the remaining 80% of the arable land. By 2020, yields from rain-dependent agriculture could decrease by 50% due to climate change. Declining glacier and ice sheet extent due to climate change will also reduce water supplies in many regions. (*see Food*).

Water security issues will present many socioeconomic and human rights challenges; and it will directly and indirectly impact many lives and livelihoods in both developed and developing nations. Climate change will impact water resources and significant water-related ecosystem services, which provide provisioning, regulating, supporting, and cultural services (*see Appendix 1 for descriptions and examples of these four types of ecosystem services*). Furthermore, conflicts over water resources will also affect human security. Local and provincial scale conflicts will arise over water rights. Increasing water demand and decreasing water supply and quality will likely increase transboundary conflicts as well as opportunities for international cooperation since 145 nations have territory within a transboundary basin.

Food

Agriculture is both an essential human activity at risk from climate change, and it is also a major driver of environmental and climate change. Agriculture has a large impact on land and water resources. Approximately 1.4 billion hectares of arable land (10% of ice-free land) are used for crop cultivation, and an additional 2.5 billion hectares are used for pasture. Environmental degradation due to climate change and human activities can disrupt the ability of ecosystems to provide services (e.g., water, food, pollination, genetic diversity for crops) necessary to maintain agriculture (*see Ecosystems*). Agriculture is also a major consumer of water, which relates to water security (*see Water*). Irrigation represents 75% of fresh water resources withdrawn from aquifers, lakes, and rivers by human activity.

The contribution of modern agricultural systems to environmental and climate change is significant. Substantial quantities of chemical inputs are applied to achieve high yields in crop production systems, which contributes to climate change, and causes significant regional pollution that impacts human and ecological health. Biofuel crop production also contributes to climate change while increasing water and food insecurity by using arable land, agrochemicals, and water resources that could be used for food production. Agricultural activities are a significant cause of deforestation (a contributor to climate change), and water and land degradation. Agriculture is also a major source of greenhouse gas emissions. Agriculture emits into the atmosphere 13 – 15 billion tonnes CO_2e per year, which is a third of the total emissions from human activities. Agriculture is the source of 25% of carbon dioxide (mainly from deforestation), 50% of methane (from rice and enteric fermentation), and more than 75% of N_2O (from fertilizer application and soil management) emitted annually by human activities.

Table 1 in *Appendix 2* shows projected major agricultural trends and impacts due to changes in climate and extreme weather events during the 21st century. **Climate change will impact food security in a variety of ways:**

Global warming. The first half of the 21st century will likely experience an average global warming of at least 1 – 2°C. This warming will reduce crop yields in seasonally dry and tropical regions. Crop and pasture yields in temperate regions may increase. However, further warming in the second half of the century will negatively impact all regions. In particular, agriculture in many developing countries in semi-tropical and tropical regions will impacted more severely.

*Extreme climate events. S*tability of food supplies are likely to be disrupted by more frequent and severe climate extremes. Increased frequency and severity of extreme climate events, such as extreme weather events, heat stress, droughts and flooding, wildfires, and pest and pathogen outbreaks, will increase negative impacts on agriculture, forestry, livestock and fisheries in all regions.

Undernourishment. In 2007, the estimated number of undernourished people worldwide was 923 million. By 2050, there will be a projected additional 2.7 billion people. By 2080, the number of undernourished people is likely to increase by 5 – 170 million people, with respect to a baseline with no climate change. Small amounts of warming and other climate changes will increase food scarcity and the risk of hunger in poor developing countries, because of negative impacts on water resources and food production and availability. Most of the increase in hunger is expected in sub-Saharan Africa.

Food stability, utilization and access. Climate change impacts, such as sea level rise, extreme weather

and social destabilization, may also affect the ability to produce and distribute food in some regions due to land loss, decreased labor pool, infrastructure loss, and other socioeconomic factors.

Growing population and food security issues are interrelated with migration, water and ecosystem security, human health, and socioecomic sustainability and poverty. In this context, climate change will likely increase food scarcity and destabilize economic and political systems, which may result in future humanitarian crises and conflict.

Economics

The impacts of climate change will not be evenly distributed across regions and within national economies – the poorest nations and people will suffer earliest and most. Climate change is a grave threat to both developed and developing nations, and it is a major challenge to continued poverty reduction. Therefore, climate change is likely to further reduce already low incomes and increase illness and mortality rates in developing countries. At a governmental level, climate change will reduce tax revenues and raise spending needs, thereby worsening public finances, services, and welfare. On a community and individual scale, climate change will impact lives and livelihoods by increasing water, food, and ecosystem stress in many areas, which will impact local economies, employment, and ways of life. Therefore, the benefits of strong, early action on climate change outweigh the costs of inaction, since the economic damages from climate change will accelerate as the world gets warmer.

The effects of climate change will affect all sectors of the economy (*see Appendix 2*). Essential infrastructure that provide reliable services and high standards of living (such as water supply and transportation) will be impacted. Ecosystems that provide essential goods and services will also be negatively impacted (*see Ecosystems*). Climate change impacts will place immense strains on public sector budgets. Secondary effects of climate impacts can include higher prices for goods and services, reduced income, and unemployment. Economic impacts on this scale could spill over national borders, which would incur further economic costs. Climate-related shocks have instigated migration and violent conflict in the past. Such conflict is a serious risk in developing, impoverished, and politically unstable areas.

Emissions have been, and continue to be, driven by economic growth. CO_2 emissions per capita are strongly correlated with per capita GDP. Since the beginning of the Industrial Revolution, North America and Europe have produced about 70% of all the CO_2 emissions from energy production, while developing countries have produced less than one quarter. With current trends, most future emissions growth will come from today's developing countries, due to their more rapid population and GDP growth and their increasing share of energy-intensive activities.

There are four interrelated components to the economical impacts of climate change: (1) the cost of mitigation, adaptation, and inaction; (2) the costs of climate change on socioeconomic stability, including unemployment, infrastructure damage and poverty; (3) the economic response to socioeconomic instability; (4) financing policies and mechanisms for mitigation, adaptation, and disaster management.

Global climate change could reduce global GDP by 20%. The costs of extreme weather events alone could reach 0.5 – 1% of global GDP per annum by the middle of the 21st century. The Stern Review estimates that the annual costs of stabilization at 500 – 550ppm CO_2e is approximately 1% (with a range of -2% to +5%) of global GDP by 2050. The transition to a low-carbon economy will challenge competitiveness, but it also create opportunities for economic growth. Therefore, reducing the projected adverse impacts of climate change is both highly desirable and feasible. Additionally, adaptation efforts in developing countries should be accelerated and supported, including through international development assistance. Ideally, these adaptation and development opportunities could benefit human security and promote the realization of human rights goals.

Health

Climate change has the potential to challenge the human right to health and to affect human health in several direct and indirect ways. Potential climate change health effects include the following issues: allergens, air quality and respiratory disease, extreme weather events, heat waves, mental health, vector-borne and zoonotic diseases, water- and food-borne diseases and contamination, malnourishment, loss of ecosystem services, injury, increased mortality, and other indirect health effects. Climate change impacts on ecosystems also threaten to reduce human access to water, foodstuff, natural medicines, and the pollution remediation services.

Climate related health impacts of decreased labor productivity, health care expenses, and the burden of the ill on families and communities could affect economic activities, lives, and livelihoods. People may be forced to relocate in order to adapt to changing health conditions, or to find better health care and economic opportunities. Health-related migration, poverty, and humanitarian crises may also provoke conflict in politically unstable regions and where resources are scarce.

Peak Resources

Peak production of energy resources (i.e., oil, coal, natural gas, and uranium), phosphorus, and rare metals and minerals may occur within the next two decades. In particular, the problems associated with global energy resource production peaking will not be temporary. It is unclear as to how the effects of peak fossil fuels and the responding human activities will affect climate change. Peak energy and phosphorus will likely impact global food and economic security. Peak metal and mineral resources will affect industrial activities and energy distribution.

Energy Resources. A shortfall of fossil fuel supplies caused by global fossil fuel production peaking will sharply increase energy prices and price volatility. Oil peaking will create a severe liquid fuels problem for the transportation sector. Oil, coal, and gas are also key strategic commodities, critical to the modern industrial economy – e.g., providing transportation and heating fuels, raw materials for agrochemicals, plastics and a myriad of other goods. Peak fossil fuels will disrupt these types of industries and associated human activities, which will also contribute to economic disruption and shortages of various industrial goods. Fossil fuel shortages and high energy prices will affect food and

water prices, availability, and distribution worldwide. Peak oil, coal, and gas will likely result in a major long-term global economic depression. Individual and collective human rights will be challenged. The number of people in poverty will likely increase. Intervention by governments will be required. Social unrest and international conflict may also threaten human rights and democratic institutions as governments resort to more authoritarian social control and economic policies. Peak fossil fuels will also have significant impacts on military and security activities, including geopolitics and the acquisition and securing of energy resources.

Coal. Coal provides over 25% of the world's primary energy needs, and generates 40% of the world's electricity. Production projections suggest the global peak of coal production will occur around 2025 at 30% above current production, in the best case.

Oil. Peak oil will likely occur without much warning time (i.e., within less than one year's time). Various estimates predict that global peak oil production will occur anytime between 2005 and 2020. The International Energy Agency has forecast a global oil supply "crunch" from 2012. Many experts and industry leaders argue that peak oil most likely occurred between 2005 – 2008, or will occur by 2015. The decline in oil production after peaking is estimated to be 6.7% – 9% per year. In order to avoid severe economic disruption, the decline in oil production rates should be less than 3% per year. Nations will need at least 20 years before peak oil occurs to make the transition away from an oil-based economy and society. Even with 20 years preparation time, significant economic disruption will likely occur.

Gas. Natural gas prices will likely link to oil prices (i.e., expensive oil will increase gas prices) within the next few years, if it has not already occurred. Therefore, peak gas production is linked to peak oil production to some extent. Although some policy-makers, industrial leaders, and the public know of peak oil production, they do not seem to be aware of impending peak gas production.

Uranium. Supplies of uranium may not be sufficient to substitute for fossil fuel generated energy. Estimates for peak uranium production range between the 1980's and 2035. In the absence of developing effective uranium recycling technologies (from spent uranium fuel and decommissioned nuclear weapons), peak uranium may be an obstacle in the development of new non-fossil fuel energy supplies.

Other Peak Resources

Peak Metals. The peak production of some metals and minerals – including copper, platinum, silver, gold, zinc, and rare metals – coupled with increasing global demand threaten to cause a major supply shortage in the coming decades. Some of these precious metals and minerals are necessary materials for electronics, energy transmission, batteries, and some green technologies. Since a shortage of metal and mineral resources may adversely affect societies ability to develop green and sustainable technologies in order to mitigate and adapt to climate change and other development challenges, it is important to investigate these peak resource issues in order to fully assess the development and economic implications.

Phosphorus. Phosphorus is an element necessary for all life. There are no substitutes for phosphorus in agriculture. Global phosphorus production most likely peaked in 1989. If global phosphorus production

has not yet peaked, it will likely do so by 2033. Global reserves will likely start to run out within 50 – 100 years. Currently, most of the world's farms do not have or do not receive adequate amounts of phosphate. Increased demand for food for the world's increasing population will accelerate the rate of depletion of phosphate reserves. Future generations will face problems in obtaining enough phosphate to survive. Once phosphorus supplies are exhausted, phosphorus will need to be recovered and reused in order to avoid a massive global food security crisis. However, since the price of phosphate rock increased dramatically worldwide due to increased agricultural demand and limited supplies of phosphate rock in 2007–2008, it is possible that a massive global food security crisis due to peak phosphorus may already be starting.

Humanitarian Issues

Since 1980, the number of people affected by extreme weather events, many of which are linked to climate change, has doubled. **By 2015, more than 375 million people are likely to be affected by climate related disasters – a projected increase of 54% – and this threatens to overwhelm the world's current capacity to respond** (*see Humanitarian Hotspots in Appendix 3*). Within seven years, emergency organizations could be overwhelmed by the increasing number of people, especially in poor nations, affected by climate hazards like floods, droughts, and storms. This figure does not include people affected by other disasters such as conflict, earthquakes, and volcanoes. Worldwide emergency aid spending will have to be nearly doubled to at least $25 billion a year to cope.

In the coming decades, climate change is expected to increase the risks of disasters from both more frequent and intense hazard events, and from greater vulnerability to the existing hazards. More frequent and intense weather events and persistent droughts can reduce existing community coping capacity to prepare, respond, and rebuild after hazard events. The other adverse impacts of climate change (e.g., on public health, ecosystems, food security, migration) will increase the vulnerability of communities to natural hazards of all types. This in turn may also exacerbate the struggle for access to and control of scarce resources, which would also increase the likelihood of migration and conflict.

Even small changes in climate can significantly increase future disaster risk in highly vulnerable, ill-prepared communities. Climate change impacts also amplify existing stresses. Impacts can contribute to the breakdown of livelihood systems, which can contribute to problems such as chronic hunger, conflict, and displacement. Integrating disaster risk reduction into development strategies in highly vulnerable areas can prevent a cycle of vulnerability in which more intense disasters reinforce vulnerability and make communities more prone to future disasters. Any increase in disasters, whether large or small, will challenge development gains, destabilize societies, and hinder the implementation human rights development programs like the Millennium Development Goals. Unfortunately, there is a lack of communication and understanding between climate scientists and the humanitarian community. Although it would be useful for the science community to align their products more carefully to humanitarian needs, humanitarian agencies do not necessarily plan beyond short-term horizons to understand the long-term consequences of climate change. Ultimately, the science needs to be integrated into humanitarian planning in order to better protect human security and rights goals.

Projected climate change poses a serious threat to national and global security. Unlike most conventional security threats that involve a single set of actors operating in specific ways and points in time, climate change can cause multiple chronic conditions occurring globally within the same time frame. Climate change has the potential to disrupt peoples' way of life and to force changes in the way nations keep themselves secure. Climate change threatens to add new hostile and stressing security factors. It has the potential to create sustained natural and humanitarian disasters on a scale far beyond those currently experienced today. The consequences will likely promote political instability where societal demands exceed the government capacity to cope. Climate-related impacts like extreme weather events, drought, flooding, sea level rise, retreating glaciers, thawing permafrost, water and food insecurity, and the rapid spread of diseases will likely cause: increased migrations, outbreaks of disease and pandemics, further weakened and failed states, expanded ungoverned spaces, exacerbated underlying conditions that terrorist groups seek to exploit, threaten human rights, increased internal conflicts and civil unrest, and increased violent and non-violent crimes. These conditions will likely disrupt local, regional, and global economic trade and introduce new security challenges globally.

Climate change acts as a threat multiplier for instability in some of the most volatile regions of the world. Projected climate change will seriously exacerbate already marginal living standards in many African, Asian, Latin American, and Middle Eastern nations, which would cause widespread political instability and increase the likelihood of failed states. Many governments in Africa, Asia, and the Middle East are already at their maximum capacity to provide basic needs, such as food, water, shelter and stability. Problems of this scale threaten to overwhelm the capacity of local authorities and security forces to respond, which could then require a larger international response.

Projected climate change will add to tensions even in stable regions of the world. North American provinces (U.S. states and Canadian provinces), European nations (including both Western and Eastern Europe, Russia, and near-East countries), Australia and the Pacific region, and small island states will also be threatened by domestic socioeconomic and political destabilization. Extreme weather events and natural disasters (e.g, Hurricane Katrina) may lead to increased domestic humanitarian and security operations for national and local governments, military, and other security forces. Additionally, the U.S. and Europe may experience increasing pressure to accept large numbers of migrant and refugee populations as climate change threatens human security and human rights in less developed regions.

Resource competition in response to climate change may threaten national and global security. Local and international competition for resources, such as water and arable land, will exacerbate the potential for conflicts in regions throughout the world. For example, the Arctic nations are discussing how to avoid potential international conflicts reminiscent of the Cold War as retreating sea ice opens up the Arctic Ocean for oil and gas exploration, international transportation, fishing, and other economic and military activities.

Governance, geopolitics, and international policy will affect human security and rights at all scales (i.e., individuals, communities, state, regional, and international). Climate change can affect global security and geopolitics in a variety of ways. Climate change impacts can increase conflict and the opportunities for cooperation due to resource scarcity, socioeconomic and humanitarian concerns, and other climate-related issues. Climate change also threatens the economic, social, and political development of both developed and developing nations, which would also affect the global economy and individual and collective human rights and security. Climate changes can weaken states, which could lead to complex domestic and international security situations. In particular, climate change impacts combined with large scale environmental degradation can also weaken, impoverish, and potentially destabilize vulnerable states.

The geopolitics of climate change is, and will likely remain, complicated. Various international and regional groups act in a disaggregated manner to influence international and regional climate policy. Oftentimes, special interests (e.g., oil industry, agriculture industry) have a powerful influence over policy negotiations (*see Special Interests*). There are many national and economic interests and negotiating blocs (e.g., G77 and China, OPEC, AOSIS, Russia) that work to push various agendas in the climate policy debates. Frequently, these agenda compete or conflict with each other. Since the most vulnerable people to climate change are generally not the main contributors to the problem, and since the detrimental and beneficial impacts of climate change are not evenly or equitably distributed, some actors desire more progressive climate action while some try to maintain the status quo. Oftentimes, agendas promoting similar interests conflict with one another due to differences in each nations special interests and sense of responsibilities. It is important to understand the different issues and interests that motivate various national and economic positions on climate change in order to effectively address the topic of geopolitics. It is also important to look at the various policies (e.g., climate, energy, economic, industrial, trade, foreign) of each nation as a whole, rather than in its constituent parts – e.g, if a nation's climate policy is at conflict with its energy and economic policies, then it is important to consider how each of these different policies might work.

The case of OPEC and the G77 is an example of subtle, but significant, conflict of interests in geopolitics and climate negotiations. OPEC is often tacitly supported in its obstructive role in climate change negotiations and international climate policy by the larger G77 coalition of developing countries. The thirteen OPEC members – particularly the Middle Eastern members – profit from high oil prices. For instance, a US$ 10 rise in the price of barrel of oil results in a 14% increase in GDP in Saudi Arabia, a 17% increase in GDP in Oman and Kuwait, and a 22% increase in GDP in the United Arab Emirates. Conversely, these gains harm oil importing developing countries – e.g., a US$ 10 increase in the price of a barrel of oil causes GDP to fall by 1.4% in India, by 1.3% in Kenya, by 1.6% in the Philippines, and by 2.8% in Jamaica. Therefore, there are significant wealth transfers between oil exporting and oil importing countries as oil prices increase.

OPEC claims that climate mitigation policies that target oil consumption will their economic growth by slowing growth in their revenues from oil exports. OPEC argues that reducing emissions through the imposition of carbon taxes or equivalent measures in developed countries will reduce demand for oil, which may lower the global price of oil. Additionally, OPEC also argues that carbon taxes in developed nations may increase the rent that governments in energy importing nations have in the oil market,

which would also transfer wealth from governments in producing nations to governments in consuming nations.

In international climate negotiations, OPEC has argued that developed nations must minimize these economic impacts by demanding compensation for their expected revenue losses. This is a main reason why there are so many complex, time consuming, and unnecessary negotiations on the issue of “the adverse effects of response measures”, which to OPEC means “compensation for lost oil revenue”. In order to protect their perceived economic interests, OPEC interfere with progressive climate policy by exercising the power of veto in the consensual negotiating process. Effectively, any party that does not want progress in the climate negotiations can object to or seek amendment to every line of text under negotiation. It is this strategy that OPEC plays in the negotiating process, often with support from the G77 and China since that group does not oppose it.

The geopolitics of climate change was made evident at the UN Conference of Parties in Copenhagen. In December 2009, UN delegates approved a motion to "take note of the Copenhagen Accord of December 18, 2009". This motion occurred because of nations, such as Bolivia, Sudan, Tuvalu and Venezuela, who registered their opposition to both the targets and process by which the Copenhagen Accord was reached. Although UN Secretary General Ban Ki-moon called the deal an "essential beginning", debate remains as to the exact legal nature of the Accord. The Copenhagen Accord, a three-page nonbinding statement, sets a target for keeping temperature rises below 2°C from pre-industrial levels, but it does not contain commitments for reduced emissions that would be necessary to achieve that goal. Part of the agreement pledges US$ 30 billion to the developing world over the next three years, increasing to US$ 100 billion per year by 2020, to help poor nations adapt to climate change, develop low-carbon energy systems, and to take steps to protect tropical forests from destruction. However, earlier and more scientifically realistic proposals were not accepted by the delegates that would have aimed to limit global temperature warming to 1.5°C and reduced CO_2 emissions by 80% by 2050. Currently, more than 100 nations have signed up under the accord.

Although it is important to consider the role of the UN Climate Change Conference for climate negotiation and policy-making, **it is also important to consider the potential governance role of other international institutions**, such as the WTO; and the various other UN institutions and conventions that can influence climate change policy and implementation, human security, and human rights – e.g., Convention on Biological Diversity (CBD), International Strategy for Disaster Reduction (ISDR), International Monetary Fund (IMF), Montreal Protocol on Substances That Deplete the Ozone Layer, Millennium Development Goals (MDG), Children's Fund (UNICEF), Convention to Combat Desertification (UNCCD), Development Programme (UNDP), and High Commissioner for Refugees (UNHCR).

Special Interests

Various special interests (i.e., industry, politicians, social and religious associations, and ruling families and elites) are actively working to prevent progressive climate action using a variety of political, social, and economic strategies. Common examples of these interests are the oil and coal industries. Another example is conservative-controlled corporate media (a.k.a. Big Media), such as News Corps. and Fox News, who often use well-organized aggressive and defamatory misinformation campaigns to confuse the public and policy-makers to oppose progressive climate action. There are other possible special interests representing a variety of sectors and agendas. One sector that may have an particular incentive to prevent climate action, or even to promote climate change, is the disaster capitalism complex, which broadly includes the military-industrial complex; security industry; reconstruction and capacity building industries; and various resource industries that could benefit from privatizing the production and distribution of scarce resources, such as certain transnational water (e.g., Vivendi) and agriculture industries (who seek to privatize arable land throughout the world, and to promote privatized genetically modified organisms for 'climate resilient' crops).

Although some of these special interests are not consciously or intentionally attempting to prevent progressive climate action, **perverse market incentives, market distortions, imperfect information, profit motives, and free-market ideologies are preventing the public and their governments from responding to the challenge of climate change in an effective and timely manner**. Given the vast and complex influence that these special interests have over the market, political processes, public opinion and information distribution, it is important that decision- and policy-makers are aware of the challenges to climate action that these interests pose.

Associated Issues

Indigenous People. There are 300 – 350 million indigenous people in the world, which is approximately less than 6% of the total global population. This number includes at least 5,000 distinct peoples. Some indigenous people are particularly vulnerable to climate change. Indigenous peoples are among the world's most marginalized, impoverished, and vulnerable people. Climate change threatens many of their livelihoods, economy, resource base, social life, traditional knowledge, and culture. Migration and territorial encroachment by other peoples threatens to increase conflict in some regions. The security of indigenous people and indigenous rights are particularly challenging issues due to the different cultural, environmental, and political contexts of each group of people.

Children. About 2.2 billion people are under the age of 18, which is approximately one third of the human population. About 85% of the world's youth live in developing countries. Many of the main causes of death of children (malaria, diarrhea, and undernutrition) are very sensitive to climatic conditions, which are expected to worsen as a result of climate change. Children are more susceptible to the adverse effects of environmental degradation than are adults. The quality of a child's environment is a key determinant of whether a child survives the first year of life and of her physical and mental development. Climate change is interrelated to the broader sustainable development agenda (e.g., the MDGs) to reduce poverty, child mortality and morbidity, and to ensure universal primary education for all children.

Children can be important agents for social change, economic development, and technological innovation. Children are potentially strong protagonists for protecting and improving the environment. Today's children and future generations will bear the burden of the climate change impacts. Therefore, the circumstances and experiences of children today set the stage for future human security. The Convention on the Rights of the Child and the '*A World Fit for Children*' Declaration (WFFC), protect and preserve the right of every child to a safe, healthy environment in which to develop and grow. Together with the Millennium Development Goals (MDGs) and other development agenda, these international commitments are particularly relevant for addressing the threats posed by climate change.

Women. Women form a disproportionately large share of the world's poor. Women in rural areas in developing nations are very dependent on local natural resources for their livelihood, because of their responsibility to acquire water, food, and fuel for cooking and heating. The effects of climate change (e.g, drought, altered precipitation, ecosystem loss) make it more difficult to secure these resources. Climate change also will challenge maternal health (e.g., maternal mortality, reproductive health and birth control) and the traditional responsibility of women to care for children (*see Children above*). By comparison with men in poor nations, women face historical disadvantages that include limited access to decision-making and economic assets that increase the challenges of climate change that they face. The Millennium Development Goals (MDGs), among other international conventions are particularly relevant for addressing the threats to women and their families posed by climate change

Development Policies. Various international and national development policies, such as the Millennium Development Goals (MDGs), may provide ways to facilitate policies and implementation goals for environmental and socioeconomic equality, sustainable development, climate change mitigation and adaptation, disaster management, humanitarian aid, conflict prevention, and other human security and human rights concerns.

Africa

Africa is one of the most vulnerable continents to climate change and climate variability, a situation aggravated by the interaction of 'multiple stresses', occurring at various levels, and low adaptive capacity. Africa's major economic sectors are vulnerable to current climate sensitivity, with huge economic impacts, and this vulnerability is exacerbated by existing developmental challenges such as endemic poverty, complex governance and institutional dimensions; limited access to capital, including markets, infrastructure and technology; ecosystem degradation; and complex disasters and conflicts. These in turn have contributed to Africa's weak adaptive capacity, increasing the continent's vulnerability to projected climate change.

African farmers have developed several adaptation options to cope with current climate variability, but such adaptations may not be sufficient for future changes of climate.

Agricultural production and food security (including access to food) in many African countries and regions are likely to be severely compromised by climate change and climate variability. A number of countries in Africa already face semi-arid conditions that make agriculture challenging, and climate change will be likely to reduce the length of growing season as well as force large regions of marginal agriculture out of production. Projected reductions in yield in some countries could be as much as 50% by 2020, and crop net revenues could fall by as much as 90% by 2100, with small-scale farmers being the most affected. This would adversely affect food security in the continent.

Climate change will aggravate the water stress currently faced by some countries, while some countries that currently do not experience water stress will become at risk of water stress. Even without climate change, several countries in Africa, particularly in northern Africa, will exceed the limits of their economically usable land-based water resources before 2025. About 25% of Africa's population (about 200 million people) currently experience high water stress. The population at risk of increased water stress in Africa is projected to be between 75 – 250 million and 350 – 600 million people by the 2020s and 2050s, respectively.

Changes in a variety of ecosystems are already being detected, particularly in southern African ecosystems, at a faster rate than anticipated. Climate change, interacting with human drivers such as deforestation and forest fires, are a threat to Africa's forest ecosystems. Changes in grasslands and marine ecosystems are also noticeable. It is estimated that, by the 2080s, the proportion of arid and semi-arid lands in Africa is likely to increase by 5 – 8%. Climate change impacts on Africa's ecosystems will probably have a negative effect on tourism as, according to one study, between 25 – 40% of mammal species in national parks in sub-Saharan Africa will become endangered.

Climate variability and change could result in low-lying lands being inundated, with resultant impacts on coastal settlements. Climate variability and change, coupled with human-induced changes, may also affect ecosystems, e.g., mangroves and coral reefs, with additional consequences for fisheries and tourism. The projection that sea-level rise could increase flooding, particularly on the coasts of eastern Africa, will have implications for health. Sea-level rise will probably increase the high

socioeconomic and physical vulnerability of coastal cities. The cost of adaptation to sea-level rise could amount to at least 5 – 10% of gross domestic product.

Human health, already compromised by a range of factors, could be further negatively impacted by climate change and climate variability, e.g., malaria in southern Africa and the East African highlands.

Arctic

In the Arctic, there is strong evidence of the ongoing impacts of climate change on terrestrial and freshwater species, communities and ecosystems, which will affect lives, livelihoods, and socioeconomic systems throughout the region. Recent studies project that such changes will continue, with implications for biological resources and globally important feedbacks to climate. Strong evidence exists of changes in species' ranges and abundances and in the position of some tree lines in the Arctic. An increase in greenness and biological productivity has occurred in parts of the Arctic. Surface albedo is projected to decrease and the exchange of greenhouse gases between polar landscapes and the atmosphere will change. Higher methane emissions responding to the thawing of permafrost and an overall increase in wetlands will enhance radiative forcing.

Components of the terrestrial cryosphere (i.e., ice, glaciers, snow) and hydrology are increasingly being affected by climate change. These changes will have cascading effects on key regional biophysical systems and cause global climatic feedbacks, and in the north will greatly impact socioeconomic systems.

Continued changes in sea-ice extent, warming and acidification of the polar oceans are likely to further impact the biomass and community composition (biodiversity) of marine biota, as well as Arctic human activities. The impact of climate change on Arctic fisheries will be regionally specific; some beneficial and some detrimental. The reduction of Arctic sea ice has led to improved marine access, increased coastal wave action, changes in coastal ecological and biological production and adverse effects on ice-dependent marine wildlife, and continued loss of Arctic sea ice will have human costs and benefits. Already Arctic human communities are adapting to climate change, but both external and internal stressors challenge their adaptive capabilities. Benefits associated with climate change will be regionally specific and widely variable at different locations. Impacts on food accessibility and availability, and personal safety are leading to changes in resource and wildlife management and in livelihoods of individuals (e.g., hunting, traveling). The resilience shown historically by Arctic indigenous peoples is now being severely tested. Warming and thawing of permafrost will bring detrimental impacts on community infrastructure. Substantial investments will be needed to adapt or relocate physical structures and communities. The benefits of a less severe climate are dependent on local conditions, but include reduced heating costs, increasing agricultural and forestry opportunities, more navigable northern sea routes, and marine access to various resources.

New evidences show that climate change has affected many sectors in Asia. The crop yield in many countries of Asia has declined, partly due to rising temperatures and extreme weather events. The retreat of glaciers and permafrost in Asia in recent years is unprecedented as a consequence of warming. The frequency of occurrence of climate-induced diseases and heat stress in Central, East, South and South-East Asia has increased with rising temperatures and rainfall variability. Observed changes in terrestrial and marine ecosystems have become more pronounced.

Future climate change is likely to affect agriculture, risk of hunger and water resource scarcity with enhanced climate variability and more rapid melting of glaciers. About 2.5 – 10% decrease in crop yield is projected for parts of Asia in 2020s and 5 – 30% decrease in 2050s compared with 1990 levels without CO_2 effects. Freshwater availability in Central, South, East and South-East Asia, particularly in large river basins such as Changjiang, is likely to decrease due to climate change, along with population growth and rising standard of living that could adversely affect more than a billion people in Asia by the 2050s. It is estimated that 120 million to 1.2 billion will experience increased water stress by the 2020s, and by the 2050s the number will range from 185 – 981 million people. Accelerated glacier melt is likely to cause increase in the number and severity of glacial melt-related floods, slope destabilization and a decrease in river flows as glaciers recede. An additional 49 million, 132 million and 266 million people of Asia could be at risk of hunger by 2020, 2050 and 2080, respectively.

The acceleration of the retreat of the Hindu Kush-Himalayan-Tibetan (HKHT) glaciers since the 1970s, in conjunction with the decrease in the summer monsoon rainfall in the Indo-Gangetic Plain region, is a major environmental problem facing Asia, threatening both the water and the food security of at least 2.5 billion people currently living in the Af-Pak region, Central, South, South East, and East Asia. The declining HKHT glaciers and snow packs provide the head-waters for Asia's major river systems, including the Indus, the Ganges, the Brahmaputra, the Mekong and the Yangtze. Projections show that most parts of South and East Asia will suffer from water stress by 2050. Climate impacts on the HKHT will likely exacerbate regional economic and political instability, and threaten humanitarian crises. Water, food, economic, and environmental stresses may provoke internal and transboundary conflict in region. Regional conflict could become particularly disastrous considering that China, India, and Pakistan are nuclear states.

Marine and coastal ecosystems in Asia are likely to be affected by sea-level rise and temperature increases. Projected sea-level rise is very likely to result in significant losses of coastal ecosystems and a million or so people along the coasts of South and South-East Asia will likely be at risk from flooding. Sea-water intrusion due to sea-level rise and declining river runoff is likely to increase the habitat of brackish water fisheries but coastal inundation is likely to seriously affect the aquaculture industry and infrastructure particularly in heavily-populated megadeltas. Stability of wetlands, mangroves and coral reefs around Asia is likely to be increasingly threatened. Recent risk analysis of coral reef suggests that between 24% and 30% of the reefs in Asia are likely to be lost during the next 10 years and 30 years, respectively.

Climate change is likely to affect forest expansion and migration, and exacerbate threats to biodiversity resulting from land use/cover change and population pressure in most of Asia.

Future climate change is likely to continue to adversely affect human health in Asia.

Multiple stresses in Asia will be compounded further due to climate change. It is likely that climate change will impinge on sustainable development of most developing countries of Asia as it compounds the pressures on natural resources and the environment associated with rapid urbanization, industrialization and economic development. Mainstreaming sustainable development policies and the inclusion of climate-proofing concepts in national development initiatives are likely to reduce pressure on natural resources and improve management of environmental risks.

Australia and New Zealand

Regional climate change has occurred. Since 1950, there has been 0.4 – 0.7°C warming, with more heatwaves, fewer frosts, more rain in north-west Australia and south-west New Zealand, less rain in southern and eastern Australia and north-eastern New Zealand, an increase in the intensity of Australian droughts, and a rise in sea level of about 70 mm.

Australia and New Zealand are already experiencing impacts from recent climate change. These are now evident in increasing stresses on water supply and agriculture, changed natural ecosystems, reduced seasonal snow cover, and glacier shrinkage.

Some adaptation has already occurred in response to observed climate change. Examples come from sectors such as water, natural ecosystems, agriculture, horticulture and coasts. However, ongoing vulnerability to extreme events is demonstrated by substantial economic losses caused by droughts, floods, fire, tropical cyclones and hail.

The climate of the 21st century is virtually certain to be warmer, with changes in extreme events. Heatwaves and fires are virtually certain to increase in intensity and frequency. Floods, landslides, droughts and storm surges are very likely to become more frequent and intense, and snow and frost are very likely to become less frequent. Large areas of mainland Australia and eastern New Zealand are likely to have less soil moisture, although western New Zealand is likely to receive more rain.

Potential impacts of climate change are likely to be substantial without further adaptation.

- As a result of reduced precipitation and increased evaporation, *water security problems are projected to intensify by 2030* in southern and eastern Australia and, in New Zealand, in Northland and some eastern regions.
- Ongoing *coastal development and population growth are projected to exacerbate risks* from sea-level rise and increases in the severity and frequency of storms and coastal flooding by 2050.
- *Significant loss of biodiversity is projected to occur by 2020* in some ecologically rich sites, including the Great Barrier Reef and Queensland Wet Tropics. Other sites at risk include Kakadu wetlands, south-west Australia, sub-Antarctic islands and alpine areas of both countries.
- *Risks to major infrastructure are likely to increase.* By 2030, design criteria for extreme events

are very likely to be exceeded more frequently. Risks include failure of floodplain protection and urban drainage/sewerage, increased storm and fire damage, and more heatwaves, causing more deaths and more blackouts.
- *Production from agriculture and forestry is projected to decline by 2030* over much of southern and eastern Australia, and over parts of eastern New Zealand, due to increased drought and fire. However, in New Zealand, initial benefits to agriculture and forestry are projected in western and southern areas and close to major rivers due to a longer growing season, less frost and increased rainfall.

Vulnerability is likely to increase in many sectors, but this depends on adaptive capacity.

- *Most human systems have considerable adaptive capacity:* The region has well-developed economies, extensive scientific and technical capabilities, disaster mitigation strategies, and biosecurity measures. However, there are likely to be considerable cost and institutional constraints to the implementation of adaptation options. Some indigenous communities have low adaptive capacity. Water security and coastal communities are the most vulnerable sectors.
- *Natural systems have limited adaptive capacity:* Projected rates of climate change are very likely to exceed rates of evolutionary adaptation in many species. Habitat loss and fragmentation are very likely to limit species migration in response to shifting climatic zones.
- *Vulnerability is likely to rise due to an increase in extreme events:* Economic damage from extreme weather is very likely to increase and provide major challenges for adaptation.
- *Vulnerability is likely to be high by 2050 in a few identified hotspots:* In Australia, these include the Great Barrier Reef, eastern Queensland, the South-West, Murray-Darling Basin, the Alps and Kakadu wetlands; in New Zealand, these include the Bay of Plenty, Northland, eastern regions and the Southern Alps.

Coastal Areas

Coasts are experiencing the adverse consequences of hazards related to climate and sea level. Coasts are highly vulnerable to extreme events, such as storms, which impose substantial costs on coastal societies. Annually, about 120 million people are exposed to tropical cyclone hazards, which killed 250,000 people from 1980 – 2000. Through the 20th century, global rise of sea level contributed to increased coastal inundation, erosion and ecosystem losses, but with considerable local and regional variation due to other factors. Late 20th century effects of rising temperature include loss of sea ice, thawing of permafrost and associated coastal retreat, and more frequent coral bleaching and mortality.

Coasts will be exposed to increasing risks, including coastal erosion, over coming decades due to climate change and sea-level rise. Anticipated climate-related changes include: an accelerated rise in sea level of up to 0.6 m or more by 2100; a further rise in sea surface temperatures by up to 3°C; an intensification of tropical and extra-tropical cyclones; larger extreme waves and storm surges; altered precipitation/run-off; and ocean acidification. These phenomena will vary considerably at regional and local scales, but the impacts are virtually certain to be overwhelmingly negative.

Degradation of coastal ecosystems, especially wetlands and coral reefs, has serious implications for the

well-being of societies dependent on the coastal ecosystems for goods and services. Increased flooding and the degradation of freshwater, fisheries and other resources could impact hundreds of millions of people, and socioeconomic costs on coasts will escalate as a result of climate change.

The impact of climate change on coasts is exacerbated by increasing human-induced pressures. Utilization of the coast increased dramatically during the 20th century and this trend is virtually certain to continue through the 21st century. The coastal population could grow from 1.2 billion people (in 1990) to 1.8 – 5.2 billion people by the 2080s, depending on assumptions about migration. Increasing numbers of people and assets at risk at the coast are subject to additional stresses due to land-use and hydrological changes in catchments, including dams that reduce sediment supply to the coast. Populated deltas (especially Asian megadeltas), low-lying coastal urban areas and atolls are key societal hotspots of coastal vulnerability, occurring where the stresses on natural systems coincide with low human adaptive capacity and high exposure. Regionally, South, South-east and East Asia, Africa and small islands are most vulnerable. Climate change therefore reinforces the desirability of managing coasts in an integrated manner.

Adaptation for the coasts of developing countries will be more challenging than for coasts of developed countries, due to constraints on adaptive capacity.

Adaptation costs for vulnerable coasts are much less than the costs of inaction.

The unavoidability of sea-level rise, even in the longer-term, frequently conflicts with present-day human development patterns and trends.

Europe

Wide ranging impacts of changes in current climate have been documented in Europe. The warming trend and spatially variable changes in rainfall have affected composition and functioning of both the cryosphere (retreat of glaciers and extent of permafrost) as well as natural and managed ecosystems (lengthening of growing season, shift of species). The observed changes are consistent with projections of impacts due to climate change.

Climate-related hazards will mostly increase, although changes will vary geographically. Winter floods are likely to increase in maritime regions and flash floods are likely to increase throughout Europe. Coastal flooding related to increasing storminess and sea-level rise is likely to threaten up to 1.6 million additional people annually. Warmer, drier conditions will lead to more frequent and prolonged droughts, as well as to a longer fire season and increased fire risk, particularly in the Mediterranean region. During dry years, catastrophic fires are expected on drained peatlands in central Europe. The frequency of rock falls will increase due to destabilization of mountain walls by rising temperatures and melting of permafrost. Without adaptive measures, risks to health due to more frequent heatwaves, particularly in central and southern Europe, and flooding, and greater exposure to vector- and food-borne diseases are anticipated to increase. Some impacts may be positive, as in reduced risk of extreme cold events because of increasing winter temperatures. However, on balance, health risks are very likely to increase.

Climate change is likely to magnify regional differences of Europe's natural resources and assets. Climate scenarios indicate significant warming, greater in winter in the North and in summer in southern and central Europe. Mean annual precipitation is projected to increase in the North and decrease in the South. Crop suitability is likely to change throughout Europe, and crop productivity (all other factors remaining unchanged) is likely to increase in northern Europe, and decrease along the Mediterranean and in south-eastern Europe. Forests are projected to expand in the North and retreat in the South. Forest productivity and total biomass is likely to increase in the North and decrease in central Europe, while tree mortality is likely to accelerate in the South. Differences in water availability between regions are anticipated to become sharper (annual average runoff increases in the North and North-west, and to decrease in the South and South-east).

Water stress will increase, as well as the number of people living in river basins under high-water stress. Water stress will increase over central and southern Europe. The percentage area under high water stress is likely to increase from 19% today to 35% by the 2070s, and the additional number of people affected by the 2070s is expected to be between 16 – 44 million. The most affected regions are southern Europe and some parts of central and eastern Europe, where summer flows may be reduced by up to 80%.

It is anticipated that Europe's natural ecosystems and biodiversity will be substantially affected by climate change. The great majority of organisms and ecosystems are likely to have difficulty in adapting to climate change. These changes will affect a variety of economic activities, including fisheries and the harvesting of biological resources, timber and fiber production, and other ecosystem services important for economic, food, and human security.

Climate change is estimated to pose challenges to many European economic sectors and is expected to alter the distribution of economic activity. Agriculture will have to cope with increasing water demand for irrigation in southern Europe. Winter heating demands are expected to decrease and summer cooling demands to increase: around the Mediterranean, two to three fewer weeks in a year will require heating but an additional two to five weeks will need cooling by 2050. Peak electricity demand is likely to shift in some locations from winter to summer. Seasonal tourism will be impacted.

Although the effectiveness and feasibility of adaptation measures are expected to vary greatly, only a few governments and institutions have systematically and critically examined a portfolio of measures.

Middle East

Human security is a constant concern in the Middle East. However, **the security threat of climate change in the Middle East is rarely discussed**. Public and political attention tends to focus on the immediate dangers that trouble the region. However, there is a growing realization among regional analysts that climate change may present a real threat to security. The Middle East is already challenged with scarce water, food insecurity, economic growth, and social and political instability each of which could be exacerbated by climate change.

Climate models are predicting a hotter, drier and less predictable climate for the region. Higher temperatures and decreased precipitation will reduce water supplies, slow the recharge rate of aquifers, raise sea levels, and make the entire region more arid. These changes will seriously impacts water, food, and environmental security. For instance, under moderate temperature increases, the flow of the Euphrates River could decrease by 30% and the Jordan River by 80% by the end of the 21st century.

Climate change may increase temperatures, decrease precipitation, and increase competition for scarce water resources. In addition to the direct impacts of climate-related water scarcity on human security, the impact of increased water scarcity may make some existing peace agreements untenable, could challenge the negotiation of new peace agreements, and could contribute to social and political instability.

Climate change may intensify food insecurity. Climate change and water scarcity could decrease agricultural productivity and make global food prices increasingly volatile as populations and food demand grow.

Climate change may hinder economic growth, which would increase poverty and social instability. As indirect consequences of climate change, higher unemployment, reduced government revenue, and increased demands on services could weaken governments' ability to provide social services and create employment. As a result, this could create the conditions for increased crime, social unrest, and extremism.

Climate change may lead to forced displacement and increased tensions over existing refugee populations. Changing precipitation patterns, increasing desertification, and declining agricultural productivity are likely to challenge rural livelihoods, increase unemployment in rural areas, and accelerate migration to urban areas. In turn, this migration could strain urban services and result in increased resentment of existing refugee populations.

Climate change could increase the militarization of strategic natural resources. Control over natural resources may become perceived as an increasingly important strategy in national security. Consequently, resource scarcity could become a pretext for increased militarization.

Both inaction and progressive action on climate change may lead to growing resentment and distrust of the West and Israel by Arab nations. If the international community is unable to come to a climate change agreement with a commitment to mitigate climate change and to help poorer nations adapt to its impacts, some in the the Arab world may increasingly perceive that the West is not acting for the common good of the global community. Nevertheless, even if the international community does agree on a fair and equitable commitment to mitigate climate change and to help poorer nations adapt, and such agreement necessarily requires a reduction of oil consumption to limit GHG emissions, some Arab nations (e.g., Saudi Arabia) may feel that the agreement is inadequate, if it does not compensate them for revenue lost due to reducing demand for oil (*see Governance and Geopolitics*). It is worth noting that any growing resentment and distrust of the West and Israel by Arab nations due to inadequate climate agreement would be somewhat ironic, because Middle Eastern OPEC nations have been blocking progressive climate change policy at the international negotiations in part to be compensated for potential oil revenue losses that might result from oil consumption limits (*see Governance and Geopolitics*).

North America has experienced locally severe economic damage, plus substantial ecosystem, social and cultural disruption from recent weather-related extremes, including hurricanes, other severe storms, floods, droughts, heatwaves and wildfires. Over the past several decades, economic damage from severe weather has increased dramatically, due largely to increased value of the infrastructure at risk. Annual costs to North America have now reached tens of billions of dollars in damaged property and economic productivity, as well as lives disrupted and lost.

The vulnerability of North America depends on the effectiveness and timing of adaptation and the distribution of coping capacity, which vary spatially and among sectors. Although North America has considerable adaptive capacity, actual practices have not always protected people and property from adverse impacts of climate variability and extreme weather events. Especially vulnerable groups include indigenous peoples and those who are socially or economically disadvantaged. Traditions and institutions in North America have encouraged a decentralized response framework where adaptation tends to be reactive, unevenly distributed, and focused on coping with rather than preventing problems. 'Mainstreaming' climate change issues into decision making is a key prerequisite for sustainability.

Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution. Sea level is rising along much of the coast, and the rate of change will increase in the future, exacerbating the impacts of progressive inundation, storm-surge flooding and shoreline erosion. Storm impacts are likely to be more severe, especially along the Gulf and Atlantic coasts. Salt marshes, other coastal habitats, and dependent species are threatened by sea-level rise, fixed structures blocking landward migration, and changes in vegetation. Population growth and the rising value of infrastructure in coastal areas increases vulnerability to climate variability and future climate change. Current adaptation is uneven and readiness for increased exposure is low.

Climate change will constrain North America's over-allocated water resources, increasing competition among agricultural, municipal, industrial and ecological uses. Rising temperatures will diminish snowpack and increase evaporation, affecting seasonal availability of water. Higher demand from economic development, agriculture and population growth will further limit surface and groundwater availability. In the Great Lakes and major river systems, lower levels are likely to exacerbate challenges relating to water quality, navigation, recreation, hydropower generation, water transfers and bi-national relationships.

Climate change impacts on infrastructure and human health and safety in urban centers will be compounded by aging infrastructure, maladapted urban form and building stock, urban heat islands, air pollution, population growth and an aging population.

Without increased investments in countermeasures, hot temperatures and extreme weather are likely to cause increased adverse health impacts from heat-related mortality, pollution, storm-related fatalities and injuries, and infectious diseases. Historically important countermeasures include early warning and surveillance systems, air conditioning, access to health care, public education, vector control, infrastructure standards and air quality management. Cities that currently experience heatwaves are expected to experience an increase in intensity and duration of these events

by the end of the century, with potential for adverse health effects. The growing number of the elderly is most at risk. Water-borne diseases and degraded water quality are very likely to increase with more heavy precipitation. Warming and climate extremes are likely to increase respiratory illness, including exposure to pollen and ozone. Climate change is likely to increase risk and geographic spread of vector-borne infectious diseases, including Lyme disease and West Nile virus.

Disturbances such as wildfire and insect outbreaks are increasing and are likely to intensify in a warmer future with drier soils and longer growing seasons. Although recent climate trends have increased vegetation growth, continuing increases in disturbances are likely to limit carbon storage, facilitate invasive species, and disrupt ecosystem services. Warmer summer temperatures are expected to extend the annual window of high fire ignition risk by 10 – 30%, and could result in increased area burned of 74 – 118% in Canada by 2100. Over the 21st century, pressure for species to shift north and to higher elevations will fundamentally rearrange North American ecosystems. Differential capacities for range shifts and constraints from development, habitat fragmentation, invasive species, and broken ecological connections will alter ecosystem structure, function and services.

Small Island States

Small islands, whether located in the tropics or higher latitudes, have characteristics which make them especially vulnerable to the effects of climate change, sea-level rise, and extreme events. Characteristics such as limited size, proneness to natural hazards, and external shocks enhance the vulnerability of islands to climate change. In most cases they have low adaptive capacity, and adaptation costs are high relative to gross domestic product (GDP).

Sea-level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. Some studies suggest that sea-level rise could lead to a reduction in island size, particularly in the Pacific, whilst others show that a few islands are morphologically resilient and are expected to persist. Island infrastructure tends to predominate in coastal locations. In the Caribbean and Pacific islands,more than 50%of the population live within 1.5 km of the shore. Almost without exception, international airports, roads and capital cities in the small islands of the Indian and Pacific Oceans and the Caribbean are sited along the coast, or on tiny coral islands. Sea-level rise will exacerbate inundation, erosion and other coastal hazards, threaten vital infrastructure, settlements and facilities, and thus compromise the socioeconomic well-being of island communities and states.

There is strong evidence that under most climate change scenarios, water resources in small islands are likely to be seriously compromised. Most small islands have a limited water supply, and water resources in these islands are especially vulnerable to future changes and distribution of rainfall. Many islands in the Caribbean are likely to experience increased water stress as a result of climate change. Reduced rainfall in summer is projected for this region, so that it is unlikely that demand would be met during low rainfall periods. Increased rainfall in winter is unlikely to compensate, due to lack of storage and high runoff during storms. Many small islands have begun to invest in the implementation of adaptation strategies, including desalination, to offset current and projected water

shortages.

Climate change is likely to heavily impact coral reefs, fisheries and other marine-based resources. Fisheries make an important contribution to the GDP of many island states. Changes in the occurrence and intensity of El Niño-Southern Oscillation (ENSO) events are likely to have severe impacts on commercial and artisanal fisheries. Increasing sea surface temperature and rising sea level, increased turbidity, nutrient loading and chemical pollution, damage from tropical cyclones, and decreases in growth rates due to the effects of higher carbon dioxide concentrations on ocean chemistry, are very likely to affect the health of coral reefs and other marine ecosystems which sustain island fisheries. Such impacts will exacerbate non climate-change stresses on coastal systems.

On some islands, especially those at higher latitudes, warming has already led to the replacement of some local species. Mid- and high-latitude islands are virtually certain to be colonized by non-indigenous invasive species, previously limited by unfavorable temperature conditions. Increases in extreme events are virtually certain to affect the adaptation responses of forests on tropical islands, where regeneration is often slow, in the short term. In view of their small area, forests on many islands can easily be decimated by violent cyclones or storms. However, it is possible that forest cover will increase on some high-latitude islands.

It is very likely that subsistence and commercial agriculture on small islands will be adversely affected by climate change. Sea-level rise, inundation, seawater intrusion into freshwater lenses, soil salinization, and decline in water supply are very likely to adversely impact coastal agriculture. Away from the coast, changes in extremes (e.g., flooding and drought) are likely to have a negative effect on agricultural production. Appropriate adaptation measures may help to reduce these impacts. In some high-latitude islands, new opportunities may arise for increased agricultural production.

New studies confirm previous findings that the effects of climate change on tourism are likely to be direct and indirect, and largely negative. Tourism is the major contributor to GDP and employment in many small islands.

There is growing concern that global climate change is likely to impact human health, mostly in adverse ways. Many small islands are located in tropical or sub-tropical zones whose weather and climate are already conducive to the transmission of diseases such as malaria, dengue, filariasis, schistosomiasis, and food- and water-borne diseases. Other climate-sensitive diseases of concern to small islands include diarrhoeal diseases, heat stress, skin diseases, acute respiratory infections and asthma.

South America

Climatic variability and extreme events have been severely affecting the Latin America region over recent years. Highly unusual extreme weather events were reported, such as intense Venezuelan rainfall (1999, 2005), flooding in the Argentinean Pampas (2000 – 2002), Amazon drought (2005), hail storms in Bolivia (2002) and the Great Buenos Aires area (2006), the unprecedented Hurricane Catarina in the South Atlantic (2004) and the record hurricane season of 2005 in the Caribbean Basin.

Historically, climate variability and extremes have had negative impacts on population; increasing mortality and morbidity in affected areas.

During the last decades important changes in precipitation and increases in temperature have been observed. Increases in rainfall in south-east Brazil, Paraguay, Uruguay, the Argentinean Pampas and some parts of Bolivia have had impacts on land use and crop yields, and have increased flood frequency and intensity. On the other hand, a declining trend in precipitation has been observed in southern Chile, south-west Argentina, southern Peru and western Central America. Increases in temperature of approximately 1°C in Mesoamerica and South America, and of 0.5°C in Brazil, were observed. As a consequence of temperature increases, the trend in glacier retreat is accelerating. This issue is critical in Bolivia, Peru, Colombia and Ecuador, where water availability has already been compromised either for consumption or for hydropower generation. These problems with supply are expected to increase in the future, becoming chronic if no appropriate adaptation measures are planned and implemented. Over the next decades Andean inter-tropical glaciers are very likely to disappear, affecting water availability and hydropower generation.

Land-use changes have intensified the use of natural resources and exacerbated many of the processes of land degradation. Almost three-quarters of the drylands are moderately or severely affected by degradation processes. The combined effects of human action and climate change have brought about a continuous decline in natural land cover at very high rates. In particular, rates of deforestation of tropical forests have increased during the last 5 years. There is evidence that biomass-burning aerosols may change regional temperature and precipitation in the southern part of Amazonia. Biomass burning also affects regional air quality, with implications for human health. Land-use and climate changes acting synergistically will increase vegetation fire risk substantially.

The projected mean warming for Latin America to the end of the century, according to different climate models, ranges from 1 – 6°C. Most general circulation model (GCM) projections indicate rather larger (positive and negative) rainfall anomalies for the tropical portions of Latin America and smaller ones for extratropical South America. In addition, the frequency of occurrence of weather and climate extremes is likely to increase in the future; as is the frequency and intensity of hurricanes in the Caribbean Basin.

Under future climate change, there is a risk of significant species extinctions in many areas of tropical Latin America. Replacement of tropical forest by savannas is expected in eastern Amazonia and the tropical forests of central and southern Mexico, along with replacement of semi-arid vegetation by arid vegetation in parts of north-east Brazil and most of central and northern Mexico due to synergistic effects of both land-use and climate changes. By the 2050s, 50% of agricultural lands are very likely to be subjected to desertification and salinization in some areas.

By the 2020s, the net increase in the number of people experiencing water stress due to climate change is likely to be between 7 – 77 million. While, for the second half of the century, the potential water availability reduction and the increasing demand from an increasing regional population would increase these figures to between 60 – 150 million.

Generalized reductions in rice yields by the 2020s, as well as increases in soybean yields, are possible when CO_2 effects are considered. For other crops (wheat, maize), the projected response to climate change is more erratic, depending on the chosen scenario. If CO_2 effects are not considered, the

number of additional people at risk of hunger under the IPCC A2 scenario is likely to reach 5, 26 and 85 million in 2020, 2050 and 2080, respectively. On the other hand, cattle and dairy productivity is expected to decline in response to increasing temperatures.

The expected increases in sea-level rise, weather and climatic variability and extremes are very likely to affect coastal areas. During the last 10-20 years the rate of sea-level rise has increased from 1 to 2-3 mm/yr in south-eastern South America. In the future, adverse impacts would be observed on: (i) low-lying areas (e.g., in El Salvador, Guyana and the coast of Buenos Aires Province in Argentina), (ii) buildings and tourism (e.g., in Mexico and Uruguay); (iii) coastal morphology (e.g., in Peru); (iv) mangroves (e.g., in Brazil, Ecuador, Colombia and Venezuela); (v) availability of drinking water on the Pacific coast of Costa Rica, Ecuador and the Rio de la Plata estuary. In particular, sea-level rise is very likely to affect both Mesoamerican coral reefs (e.g., in Mexico, Belize and Panama) and the location of fish stocks in the south-east Pacific (e.g., in Peru and Chile).

Future sustainable development plans should include adaptation strategies to enhance the integration of climate change into development policies. Some countries have made efforts to adapt, particularly through conservation of key ecosystems, early warning systems, risk management in agriculture, strategies for flood, drought and coastal management, and disease surveillance systems. However, the effectiveness of these efforts is outweighed by: a lack of basic information, observation and monitoring systems; lack of capacity-building and appropriate political, institutional and technological frameworks; low income; and settlements in vulnerable areas; among others. Without improvements in these areas, the Latin America countries' sustainable development goals will be seriously compromised, adversely affecting, among other things, their ability to reach the Millennium Development Goals.

Urban Areas

Hundreds of millions of urban dwellers nations are at risk from the direct and indirect impacts of climate change. Without effective, locally driven adaptation, there will be very serious consequences for them and for national economies. There are important connections between successful adaptation to climate change and successful local development. Reductions in poverty, including improvements in housing and living conditions and in provision for infrastructure and services, are central to adaptation.

Urban vulnerabilities. The scale of the devastation to urban populations and economies caused by extreme weather events in recent years highlights their vulnerabilities. Worldwide, there has been a rapid growth in the number of people killed or seriously impacted by storms and floods and also in the amount of economic damage caused; a large and growing proportion of these impacts are in urban areas in low- and middle-income nations. Climate change is likely to have been a factor in much of this, but even if it was not, it is proof of the vulnerability of urban populations to weather events whose frequency and intensity climate change is likely to increase in most places. Climate change will also bring other less dramatic stresses such as heat waves and, for many urban areas, reductions in freshwater availability; also sea-level rise for all coastal cities.

The scale of the population at risk. A large and growing proportion of those most at risk from climate

change live in urban areas. **More than a third of the world's total population lives in urban areas in low- and middle-income nations.** These nations now have most of the world's urban population and most of the largest cities. Their urban centers will house most of the growth in the world's population over the next few decades and how this is planned for and managed has very large implications for the extent to which adaptation limits the costs of climate change.

Since 1950, there has been a sevenfold increase in the urban populations of low- and middle-income nations and a much-increased concentration of people and economic activities in low-lying coastal zones or other areas at risk from flooding and extreme weather events. The last 50 years has also brought a very large increase in the number of urban dwellers living in poverty, lacking provision for the basic infrastructure and services that should protect them from environmental health hazards and disasters – and which should form the basis for protection from most impacts related to climate change. **Around one billion urban dwellers live in poor-quality, overcrowded housing in "slums" or informal settlements**, and a high proportion of these settlements are on sites at risk from flooding or landslides.

The economic costs without adaptation. Successful national economies depend on well-functioning and resilient urban centers. Urgent action is needed now both to address urban centers' current vulnerabilities to extreme weather and to build into expanding urban centers protection from likely future changes.

The vulnerability of urban populations to climate change; and the relationship between urban and rural vulnerabilities. Too little attention has been given to the vulnerability of urban populations to climate change – and especially to the vulnerability of their low-income populations. The need for more attention to this does not imply that rural populations' vulnerabilities should be given less attention; indeed, a high proportion of the people whose lives and livelihoods are most at risk from climate change are rural dwellers. It is also inappropriate to consider rural and urban areas separately, given the dependence of urban centers on rural ecological services, the importance for many urban economies of rural demand for goods and services, and the reliance of much of the rural populations on urban centers for access to markets, goods and services.

Appendix 1

Ecosystems and Biodiversity

Biological diversity or **biodiversity** means *"the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"* (CBD, Article 2). The term includes all the variety of life that can be found on Earth (plants, animals, fungi, microorganisms), the diversity of biological communities that they form, and the habitats in which they live. Biodiversity includes three levels of diversity: ecosystem diversity (i.e., variety of ecosystems), species diversity (i.e., variety of different species), and genetic diversity (i.e., variety of genes within species).

Ecosystem means *"a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit"* (CBD, Article 2). Each ecosystem is a complex relationship between living (biotic), and non-living (abiotic) components (resources) such as sunlight, energy resources (geothermal heat, chemical-derived energy), air, water, minerals and nutrients. The quantity, quality, and diversity of species (richness, rarity, and uniqueness) each have an important role in a given ecosystem and its associated ecosystems. The functioning of an ecosystem often relies on a number of species or groups of species that perform certain functions (e.g, pollination, predation, grazing, nitrogen fixing).

Ecosystem services refer to *the benefits that people (or other organisms) obtain from ecosystems* (Millennium Ecosystem Assessment 2005). These include: *provisioning services* (e.g., food, materials, fuel, water); *regulating services* (benefits obtained from ecosystem processes that regulate other natural systems like climate, floods, disease, waste, and water quality); *supporting services* necessary for the production of all other ecosystem services (e.g., soil formation, photosynthesis, nutrient cycling); and *cultural services* (e.g., recreation, aesthetic enjoyment, tourism, spiritual and ethical values).

For instance, *water-related ecosystem services* include: Provisioning services directly supply food and non-food products from water flows. Climate change will affect provisioning services such as freshwater supplies; crop, livestock, and fish production; and hydro-electric power. Regulating services regulate flows or reduce hazards. Examples of climate change impacts on regulating services include affecting the buffering of runoff, soil water infiltration, groundwater, and maintenance of base flows; flood prevention, peak flow reduction, landslide reduction; soil protection and control of erosion and sedimentation; and control of surface and groundwater quality. Supporting services provide to support habitats and ecosystem functioning. Climate change will affect supporting services for wildlife habitat and such services as the flow regime required to maintain downstream habitat and uses. Cultural services that relate to recreation and human inspiration such as landscape aesthetics, cultural heritage and identity, and aquatic recreation.

In general, *biodiversity increases ecosystem productivity.* For example,

- A larger number of plant species means a greater crop variety and resilience to disease and climate change.
- Greater species diversity enhances natural sustainability for all species.
- Healthy ecosystems are more resilient to a variety of disasters.

Biodiversity provides various ecosystem services, such as

- Protection of water resources
- Soils formation and protection
- Nutrient storage and recycling
- Pollution breakdown and absorption
- Contribution to climate stability
- Maintenance of ecosystems
- Recovery from extreme events

Biodiversity provides biological resources, such as

- Food
- Medicinal resources and pharmaceutical drugs
- Wood products and fiber
- Breeding stocks, population reservoirs for crops, livestock, and bushmeat
- Future resources
- Diversity in genes, species and ecosystems. Genetic diversity helps to reduce the chances of species extinction in the wild.

Appendix 2

Projected Major Sectoral Trends and Impacts Due to Climate Change

Table 1: Projected major sectoral trends and impacts due to changes in climate and extreme weather events during the twenty-first century (not taking into account adaptive capacity), adapted *from: IPCC (2007) Technical Summary: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*.

Phenomenon and direction of trend	**Likelihood of future trends**	**Major projected impacts by sector**			
		Agriculture, forestry and ecosystems	*Water resources*	*Human health*	*Industry, settlement and society*
Warmer, fewer cold days and nights, more frequent hot days and nights	Virtually certain	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water resources relying on snowmelt; effects on some water supplies	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells and heat waves with frequency increasing in most land areas	Very likely	Reduced yields in warmer regions because of heat stress; increased wildfire danger	Increased water demand; water quality problems, e.g. algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially isolated	Reduced quality of life for people in warm areas without appropriate housing; impacts on the elderly, very young and poor

Heavy precipitation events with frequency increasing in most areas	Very likely	Damage to crops, soil erosion, inability to cultivate land due to soil waterlogging	Adverse effects on quality of surface and groundwater; contamination of water supply; less water scarcity	Increased risk of deaths, injuries and infectious, respiratory and skin diseases	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures; loss of property
Area affected by drought increases	Likely	Land degradation; lower yields, crop damage and failure; increased livestock deaths; increased wildfire risk	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water and foodborne diseases	Water shortage for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Intense tropical cyclone activity increases	Likely	Damage to crops; trees uprooted; damage to coral reefs, coastal ecosystems and communities	Disruption of public water supply from power outages	Increased risk of deaths, injuries, water- and food-borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; private insurers withdraw risk coverage in vulnerable areas; loss of property; potential for population migration
Increased incidence of extremely high sea level (excludes tsunamis)	Likely	Salinization of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risk of injury and death by drowning in floods; migration related health effects	Costs of coastal protection vs. costs of land-use relocation; potential for movement of populations and infrastructure; see tropical cyclones above

Appendix 3

Humanitarian Hotspots[1]

Until 2030, the major concern for humanitarian actors is likely to be developing areas already subject to extreme weather and with high human vulnerability. The largest and most important regions of high overall human vulnerability are in: Africa, particularly the Sahel, Horn of Africa and Central Africa; Central and South Asia, particularly Iran, Afghanistan, Pakistan, India and the Caspian region; and Southeast Asia, particularly Myanmar, Laos, Cambodia and Indonesia. Although this appendix focuses on developing regions, developed regions will also be vulnerable to extreme weather events, such as coastal regions in the lower U.S. and in Europe. Changing weather patterns will also make the occurrence and distribution of hazards increasingly unpredictable, which will increase the risk that communities not used to coping with hazard events will become disaster victims.

Flood-risk hotspots occur in: Africa, including the Sahel, the Horn of Africa, Great Lakes region, Central Africa and Southeast Africa; Central, South and Southeast Asia; and Central America and the western part of South America.

Drought-risk hotspots are mainly located in sub- Saharan Africa; South Asia, particularly Afghanistan, Pakistan and parts of India; and South East Asia, particularly Myanmar, Vietnam and Indonesia.

Cyclone and hurricane risk hotspots include Mozambique and Madagascar, Central America, Bangladesh, parts of India, Vietnam and several other Southeast Asian countries.

Several parts of the world are hotspots for more than one of the three hazard types. These regions include much of sub-Saharan Africa, especially the east coast and southeast Africa, and much of South and Southeast Asia.

[1] *Humanitarian Hotspots* adapted from: (OCHA) United Nations Office for the Coordination of Humanitarian Affairs (2008). *Humanitarian Implications of Climate Change: Mapping Emerging Trends and Risk Hotspots for Humanitarian Actors.* UN OCHA.)

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Further Reading

Climate-related Hazards and Vulnerability

- Climate Change and its Humanitarian Impacts (Stockholm Environment Institute, 2009)
- Sea Level Rise and the Vulnerability of Coastal Peoples (UNU-EHS, 2009)
- Climate Vulnerability and Capacity Analysis Handbook (Care International, 2009)
- Convenient Solutions to an Inconvenient truth: Eco-system Based Approaches to Climate Change (World bank, 2009)
- Under the Under the weather and the rising tide: adapting to a changing climate in Asia and the Pacific (ADB, 2009)
- Climate change, human impact report: the anatomy of a silent crisis (GHF, 2009)
- Global Climate Risk Index 2009 (Germanwatch, 2009)
- Complexity and Context as the Determinants of the Future (Feinstein International Center, 2008)
- Global Trends Workbook 2008 (Humanitarian Futures Programme, 2008)
- Humanitarian Implications of Climate Change (Short Version) (Maplecroft/CARE/OCHA, 2008)
- Humanitarian Implications of Climate Change (Long Version) (Maplecroft/CARE/OCHA, 2008)
- Dangerous Climate Change: rising sea levels and ocean circulation changes (McGuire, 2008)
- Crisis and risk (ODI, 2008)

- Human Development Report 2007/2008, Fighting climate change: Human solidarity in a divided world (UNDP, 2008)
- Coastal systems and low-lying areas (Ch. 6 of IPCC 4AR, WGII) (Nicholls et al, 2007)
- Climate change: Impacts, vulnerabilities and adaptation in developing countries (UNFCCC, 2007)
- Climate Change and Natural Disasters (European Parliament, 2005)
- Coastal flooding and wetland loss in the 21st century (Nicholls , 2004)
- Floods, health and climate change: a strategic review (Tyndall Centre, 2004)

Food Security

- How to Feed the World in 2050 (FAO, 2009)
- Climate change: Impact on agriculture and costs of adaptation (IFPRI, 2009)
- Economy-wide Impacts of Climate Change on Agriculture in Sub-Saharan Africa (IFPRI, 2009)
- State of World Fisheries and Aquaculture (FAO, 2009)
- Vulnerability of national economies to the impacts of climate change on fisheries (World Fisheries Trust, 2009)
- Climate Change, Food Security and the Right to Adequate Food (Bals, Harmeling and Windfuhr, 2008)
- Climate change and food security: A framework document (FAO, 2008)
- Framework for Action (UN High Level Taskforce on the Global Food Security Crisis , 2008)
- Food, fibre and forest products (Ch. 5 of IPCC 4AR, WGII) (Easterling et al, 2007)
- Global food security under climate change (Schmidhuber and Tubiello, 2007)
- Effects of climate change on global food production under SRES emissions and socio-economic scenarios (Parry et al, 2005)

Water Security

- Hydro climatic disasters in water resources management: training manual(Cap-Net, Nile IWRM-Net, UNISDR, OCHA, 2009)
- Climate change, water and food security (Ludi, 2009)
- Freshwater Under Threat: South Asia (UNEP, 2009)
- Freshwater resources and their management (Ch. 3 of IPCC 4AR, WGII) (Kundzewicz et al, 2007)
- Climate change and global water resources: SRES emissions and socio-economic scenarios (Arnell, 2004)

Health

- Global climate change: implications for international public health policy (Campbell-Lendrum et al, 2009)
- Managing the Health Effects of Climate Change (UCL, 2009)
- Protecting Health from Climate Change (WHO, 2008)

- Human Health (Ch. 8 of IPCC 4AR, WGII) (Confalonieri et al, 2007)
- Climate change: Quantifying the health impact at national and local levels (WHO, 2007)
- Climate Change Futures Health, Ecological and Economic Dimensions (Harvard Medical School, 2005)
- Climate change and human health - risks and responses (WHO, 2003)

Security and Conflict

- Rising temperatures, rising tension: climate change and the risk of violent conflict in the Middle East (IISD, 2009)
- From Conflict to Peacebuilding: The Role of Natural Resources and the Environment (UNEP, 2009)
- Climate Change and International Security (European Commission, 2008)
- Shared Destinies: Security in a globalised world (IPPR Commission on National Security in the 21st Century, 2008)
- World in transition: climate change as a security risk (WBGU, 2008)
- Climate Change and Human Security (Wisner et al, 2007)
- Climate change as the 'new' security threat: implications for Africa (Brown, Hammill and Mcleman, 2007)
- National Security and the Threat of Climate Change (CNA Cooperation, 2007)
- The Security Implications of Climate Change (Podesta and Ogden, 2007)

Displacement and Migration

- Crisis or adaptation? Migration and climate change in a context of high mobility (Tacoli, 2009)
- In Search of Shelter: mapping the Effects of Climate Change on Human Migration and Displacement (Care International, Ciesin, UNHCR, UNU, World Bank 2009)
- Confronting Environmental Migration (UNU, 2009)
- Linking Environmental Change, Migration & Social Vulnerability (UNU, 2009)
- Climate change and displacement (Forced Migration Review, 2008)
- Environmentally Displaced People (Boano, Zetter and Morris, 2008)
- Environmentally induced migration and displacement: a 21st century challenge (Council of Europe, 2008)
- Expert Seminar: Migration and the Environment, International Dialogue on Migration N°10 (IOM and UNFPA, 2008)
- Future Floods of Refugees (Norwegian Refugee Council, 2008)
- Migration Research Series No. 33: Climate Change and Migration: Improving Methodologies to Estimate Flows (IOM, 2008)
- Climate change and forced migration: Observations, projections and implications (Brown, 2007)
- Control, Adapt or Flee: How to Face Environmental Migration? (Renaud et al, 2007)
- Migration Research Series No. 31: Migration and Climate Change (IOM, 2007)
- Preparing for a warmer world (Biermann and Boas, 2007)

Costs and Financing of Adaptation

- The Costs to Developing Countries of Adapting to Climate Change New Methods and Estimates (World Bank, 2009)
- Beyond Aid: Ensuring adaptation to climate change works for the poor (Oxfam, 2009)
- Financing mitigation and adaptation by developing countries (UNDESA, 2009)
- Impact Estimation of Disasters: A Global Average for 1960 to 2007 (World Bank, 2009)
- Financing a Global Deal on Climate Change (UNEP Finance Initiative, 2009)
- The humanitarian costs of climate change (Feinstein International Center, 2008)
- From Risk to Resilience: Costs and Benefits of Disaster Risk Reduction under a Changing Climate (ISET and IIASA, 2008)
- The Economics of Climate Change: Methodology Report (World Bank, 2008)
- The Cost of Extreme Events in 2030 (Dlugolecki, 2007)
- Costs and benefits of disaster risk reduction (UNISDR, 2007)
- Stern Review on the Economics of Climate Change (Stern, 2006)
- Natural Disaster and Disaster Risk Reduction Measures (DFID, 2005)

Gender and Vulnerable Groups

- State of world population 2009 - Facing a changing world: women, population and climate (UNFPA, 2009)
- Stories from the Pacific: the gendered dimensions of disaster risk management and adaptation to climate change (AusAid, UNDP, 2009)
- Children, young people unite online to address climate change (UNICEF, 2009)
- Climate Change and Children: a Human Security Challenge (UNICEF, 2008)
- Gender Perspectives: Integrating Disaster Risk Reduction into Climate Change Adaptation (UNISDR, 2008)
- Gender, Climate Change and Human Security: Lessons from Bangladesh, Ghana and Senegal (WEDO, 2008)
- Gender: The missing component of the response to climate change (FAO, 2007)
- Gender and climate change: Women as agents of change (IUCN, 2007)
- The Gendered Nature of Natural Disasters (Neumayer and Plumper, 2007)
- Legacy of disasters: The impact of climate change on children (Save the Children, 2007)
- Biopolitics, climate change and water security: impact, vulnerability and adaptation issues for women (Tandon, 2007)

Human Rights

- Human Rights and Climate Change: Practical Steps for Implementations (CIEL, 2009)
- Report of the Office of the UNHCHR on the relationship between climate change and human rights (OHCHR, 2009)
- Climate Change and Human Rights: Report for OHCHR (Dutch section of the International Commission of Jurists, 2008)
- Resolution 7/23 on human rights and climate change (Human Rights Council, 2008)
- Climate Change and Human Rights: A Rough Guide (International Council on Human Rights Policy, 2008)
- Climate Wrongs and Human Rights Putting people at the heart of climate-change policy (Oxfam, 2008)
- The human rights impact of climate change (OHCHR, 2007)

Risk Reduction

- GFDRR Track 1, building global and regional partnership: giving risk reduction a regional dimension (UNISDR, 2009)
- Disaster risk reduction and climate change adaptation: closing the gap (DFID, 2008)
- Convergence of disaster risk reduction and climate change adaptation (DFID, 2008)
- Climate change adaptation, disaster risk reduction and social protection: a briefing note (DFID/IDS, 2008)
- DRR, climate change adaptation and human security (Global Environmental Change and Human Security, 2008)
- Bridging the gap: integrating climate change and disaster risk reduction (IFRC, 2008)

- A framework for community safety and resilience - in the face of disaster risk (IFRC, 2008)
- Disaster Risk Reduction, Climate Change Adaptation and Human Security (O'Brien et al (University of Oslo), 2008)
- Linking climate change adaptation and disaster risk reduction (Tearfund, 2008)
- Climate Change and Disaster Risk Reduction (UNISDR, 2008)
- Links between disaster risk reduction, development and climate change (UNISDR, 2008)
- Disaster risk and climate change (UNISDR, 2008)

Risk Management

- Catalyzing climate and disaster resilience: processes for identifying tangible and economically robust strategies (Monech et al, 2009)
- The human dimension of climate adaptation: the importance of local and institutional issues (Christoplos et al, 2009)
- Climate change and disaster management (FAO, 2008)
- Disaster preparedness for climate change in Nicaragua: case study (IFRC, 2008)
- Early Warning Early Action (IFRC, 2008)
- Disaster Preparedness for Effective Response (2008) (OCHA/ISDR, 2008)
- Climate change and disaster risks: ISDR recommendations for action now and post-Kyoto (UNISDR, 2008)
- Community level adaptation to climate change (van Aalst, Cannon and Burton, 2008)
- Data against natural disasters: establishing effective systems for relief, recovery and reconstruction (World Bank, 2008)
- Planet prepare: Asia Pacific disaster report (World Vision International, 2008)
- Linking Climate Change Adaptation and Disaster Risk Management for Sustainable Poverty Reduction (MWH Global, 2006)
- Managing Climate Risk: Integrating Adaptation into World Bank Group Operations (World Bank, 2006)
- Hazards of Nature, Risks to Development: An IEG Evaluation of WB Assistance for Natural Disasters (World Bank, 2006)

Risk Transfer

- Index Insurance and Climate Risk: prospects for Development and Disasters Management (International Research Institute for Climate & Society, 2009)
- Adaptation to Climate Change: Linking Disasters Risk Reduction and Insurance (UNISDR, 2009)
- The Role of Risk Transfer and Insurance in DRR and Climate Change Adaptation (CCCD, 2008)
- Climate Change: What Role for Insurance? (IIASA, 2008)
- Climate risk insurance for poverty reduction and development (International Research Institute for Climate and Society, 2008)
- Insurance Instruments for Adapting to Climate Risks (Munich Climate Insurance Initiative, 2008)

- Cover against poverty - microinsurance to cover climate risk (Munich Re, 2008)
- The attribution problem and risk transfer (Warner and Hoeppe, 2008)
- Index insurance for climate risk management and poverty reduction: Topics for debate (IRICS, 2007)
- The Landscape of Microinsurance in the World's 100 Poorest Countries (MicroinsuranceCenter, 2007)

Humanitarian Concerns and the UNFCCC Process

- Climate change adaptation strategies for local impact (IFRC, RC/RC Climate Centre, ProVention Consortium, 2009)
- Climate change and statelessness (UNHCR, IOM, NRC, 2009)
- Forced displacement in the context of climate change: Challenges for states under international law (UNHCR, NRC, RSG on the HR of IDPs, UNU-EHS, 2009)
- Protecting the health of vulnerable people from the humanitarian consequences of climate change and climate related disasters (WHO, IOM, World Vision, UNHCR, IFRC, 2009)
- Facilitating an International Agreement on Climate Change: Adaptation to Climate Change (Global Leadership for Climate Action, 2009)
- Conclusions on the further development of the EU position on a post-2012 climate agreement (Council of the EU, 2009)
- Climate change, migration, and displacement: impacts, vulnerability, and adaptation options (IOM, UNHCR et al, 2009)
- Fulfilment of the Bali Action Plan and components of the agreed outcome. Note by the Chair. Part I. (UNFCCC, 2009)
- Fulfilment of the Bali Action Plan and components of the agreed outcome. Note by the Chair. Part II. (UNFCCC, 2009)
- Climate Change, Migration and Displacement: Who will be affected? (IASC/OCHA, 2008)
- The Nairobi Work Programme Second Phase (UNFCCC, 2008)
- Why humanitarian agencies should get engaged in the UN climate change negotiations (UNISDR and others, 2008)
- DRR strategies and risk management practices: critical elements for adaptation to climate change (UNISDR/IASC, 2008)
- A Guide to the Climate Change Convention Process (UNFCCC, 2002)