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The Greater Mekong and Climate Change:

Biodiversity, Ecosystem Services and Development at Risk

October 2009

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Greater Mekong is destined for major changes due to climate change, making it one of the most vulnerable places on Earth. Changes are already occurring and the worst is yet to come.

For the Greater Mekong, climate change compounds existing and projected threats affecting the region's people, biodiversity and natural resources. This is likely to have cascading effects, for example, water scarcity leading to reduced agricultural productivity, leading to food scarcity, unemployment and poverty.

Among lower Mekong Basin countries, Laos and Cambodia are identified as the most vulnerable in part because of their limited capacity to cope with climate related risks (Yusuf and Francisco 2009). In all countries, climate change complicates existing problems.

The city of Bangkok is sinking by 5-10 mm each year. Land subsidence and groundwater extraction combined with sea level rise could leave Bangkok under 50-100 cm of water by 2025. (UNEP 2009)

Across the region, temperatures are rising and have risen by 0.5 to 1.5ºC in the past 50 years. While rainy seasons may contract over parts of the region, overall rainfall is expected to rise. This means more intense rain events when they occur.
More frequent and damaging droughts and floods will cause, and have already caused, extensive damage to property and loss of life. Sea level rise is threatening the region's coastal communities and ecosystems are becoming more stressed.

Glacial melting in the Himalayas may cause impacts to the region's major river flows and wetlands will either dry up or flood out. These impacts are already occurring to some extent.

The agricultural sector is being significantly affected by changes in climate. Warmer temperatures have contributed to declining crop yields. Storms, floods and droughts are destroying entire harvests.

Prolonged and unpredictable droughts are expected to become more problematic in the future. Water availability in the dry season will decrease and prolonged droughts will cause water shortages. Water scarcity will constrain agricultural production and threaten food security.

The human impact of climate change is devastating and the region's poorest people are disproportionately affected (Oxfam 2008). Impacts include mortality due to heat waves and increases in the number of cases and geographic shifts in infectious diseases such as malaria, dengue fever, cholera and hepatitis.

The impacts of climate change are already causing migration and displacement of people, the scope and scale of which could vastly exceed anything that has occurred before.

Maintaining diverse and healthy ecosystems is essential to maximizing ecological resilience to climate change.

Mekong countries must prepare or face devastating consequences

Deep and immediate cuts in green house gas emissions are vital to prevent the worst impacts of climate change. Nevertheless, some impacts are inevitable and some have already begun.

All the CO2 pumped into the atmosphere during the last 200 years has committed the Earth to at least another 0.8˚C temperature increase over the next century. This is why action on global climate change is critical now.

"Our children and grandchildren will never forgive us unless action is taken. Time is running out, we only have two months before Copenhagen." Abhisit Vejjajiva, Prime Minister of Thailand, keynote speech UNFCCC meeting Bangkok

The Greater Mekong region must take decisive action and prepare for the inevitable impacts of climate change today, otherwise face devastating consequences.

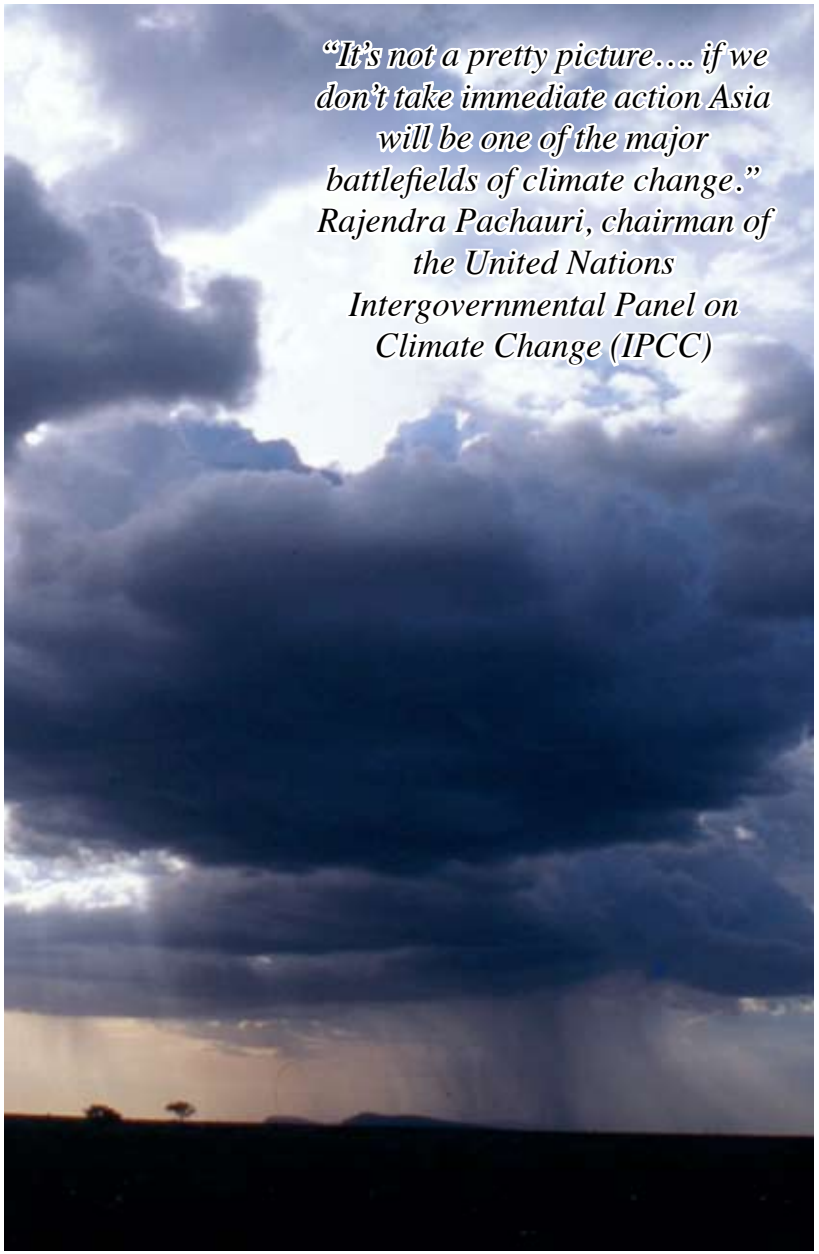
A region-wide commitment to address the threats projected for the coastal, freshwater and terrestrial ecosystems is vital. Coordination and collaboration among stakeholders is fundamental to reducing stresses on natural resources and people. Sharing information is also critical to build capacity and understanding.
People, culture and ecosystems have a right to survive. There are a number of policy actions, which if adopted by the regions leaders, will help the Greater Mekong countries minimize the crisis for current and future generations.

"As a country that emits a relatively negligible level of greenhouse gases, we are nonetheless committed to playing a part in the global effort to address climate change."
Dr Thongloun Sisoulith, Lao PDR Deputy Prime Minister and Minister of Foreign Affairs, Vientiane Times 24/9/09

Asia's first regional climate change adaptation agreement

To help Greater Mekong nations prepare for the inevitable impacts of climate change, this agreement should:

- Emphasize ecosystem-based adaptation approaches that maintain the resilience of the region
- Strengthen existing governance structures and ensure participation of all stakeholders in preparing for climate change
- Act now to use existing knowledge to address climate change
- Include mitigation in adaptation strategies
- Ensure adequate resources are available for adaptation initiatives



Will the present trajectory of unfettered growth in global greenhouse gas emissions make this region largely uninhabitable by the end of the century?

To avoid this, WWF urges the governments of the Greater Mekong region to help forge the strongest possible international agreement to halt climate change.

Limiting global warming to well below 2˚C above pre-industrial temperatures by 2100 will help avoid the worst impacts of climate change. Achieving this goal will require steep and immediate cuts in global GHG emissions.

By 2020, global GHG emissions must be brought back to1990 levels. By 2050 global emissions must be 80% below 1990 levels.

To reach these targets, WWF and a broad coalition of stakeholders are urging the richest and most developed countries to cut their emissions to 40% below 1990 levels by 2020 and developing countries to reduce their emissions by 30% from business-as-usual levels by 2020.

These goals are achievable with strong political leadership, participation by all countries, and the sense of urgency this report conveys.

THE CHALLENGE: CLIMATE CHANGE

Climate change is one of the defining issues of our time, and is set to radically transform the world in which we live.

Greenhouse gas (GHG) emissions – from various sources including combustion of fossil fuels, forest destruction, and unsustainable agriculture practices – are causing the planet to warm, altering its overall climate. Observed increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level all confirm this change in the earth's climate (IPCC 2007). As GHG emissions increase so do the changes in climate and the associated impacts on natural and human systems. Deep and immediate cuts in global emissions are needed to avoid the worst impacts of climate change.

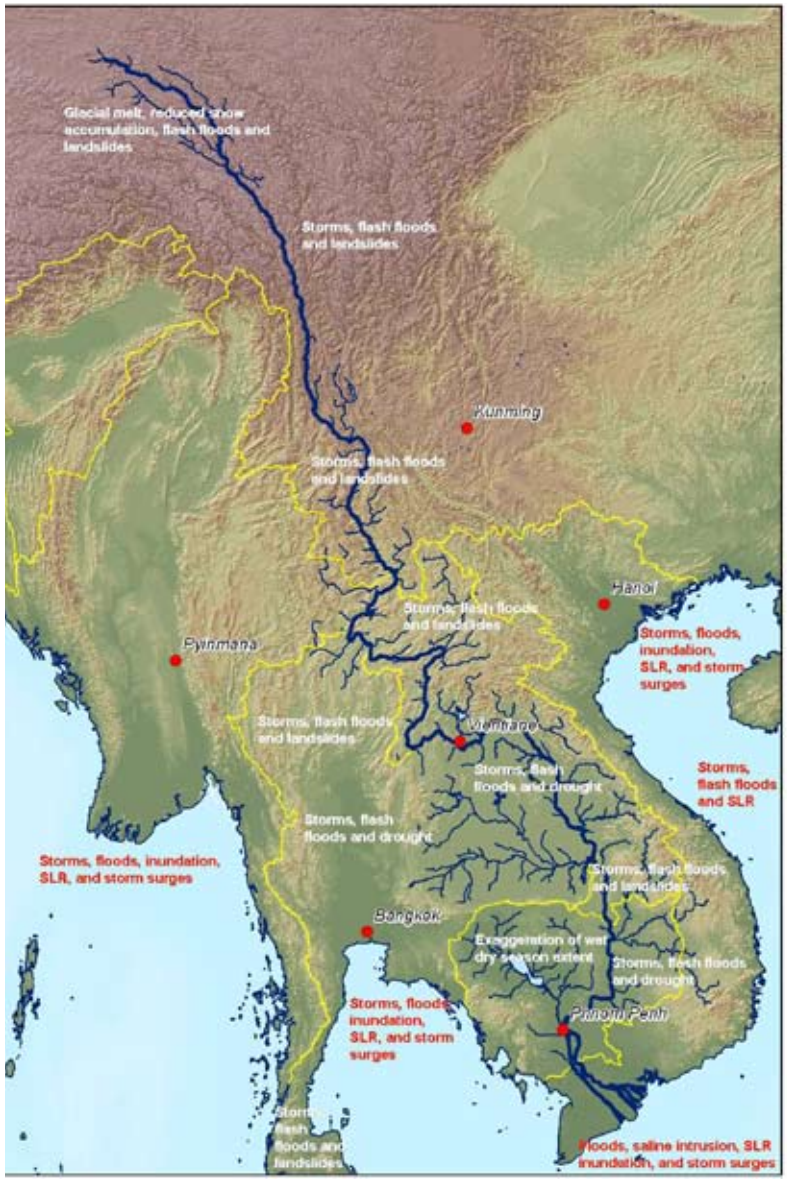
The Southeast Asian region contributed 12% of the world's greenhouse gas (GHG) emissions in 2000, an increase of 27% from 1990, which was faster than the global average (ADB 2009). In recent years, the Greater Mekong Sub-Region (GMS) has been contributing about 4.5% (about 2.2 Gigatonnes) of total GHG emissions (ADB 2008). Although the Mekong region accounts for a relatively minor share of global GHG emissions, it is one of the most rapidly developing areas in the world.

A transition to a low carbon economy would help reduce the global impacts of climate change as well as the regional and local impacts, which, as this report indicates, will become considerably worse over time. Adaptation strategies are also needed now because many of these impacts will be unavoidable.

The Mekong region's heavily populated coastal areas are especially at risk from saltwater intrusion, inundation from rising seas, and more extensive floods arising from greater peak flows of the Mekong, Red, Chao Phraya and other rivers.

Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in the region due to disruption of the hydrological cycle.

Although more annual runoff is expected from an increase in total precipitation, periods and pockets of water stress are likely by the 2050s (IPCC 2007). The ecosystems on which the people of this region depend will change dramatically as species respond in different ways to the combination of these climate impacts.



Changes have already begun

Recent studies show the emergence of general trends in the climate of the Greater Mekong Region, which have allowed scientists to project how conditions will change over the next 50 to 100 years (Eastham *et al*. 2008, ADB 2009, TKK and START 2009, WWF Australia 2009).

Many scientists are now concluding that these predictions are gross underestimates and that the region will likely experience the upper extremes of the climate scenarios forecast in the last IPCC assessment, resulting in impacts more severe than those predicted by the IPCC in 2007 (WWF Australia 2009).

What are some of the changes already being observed in the Greater Mekong Region?

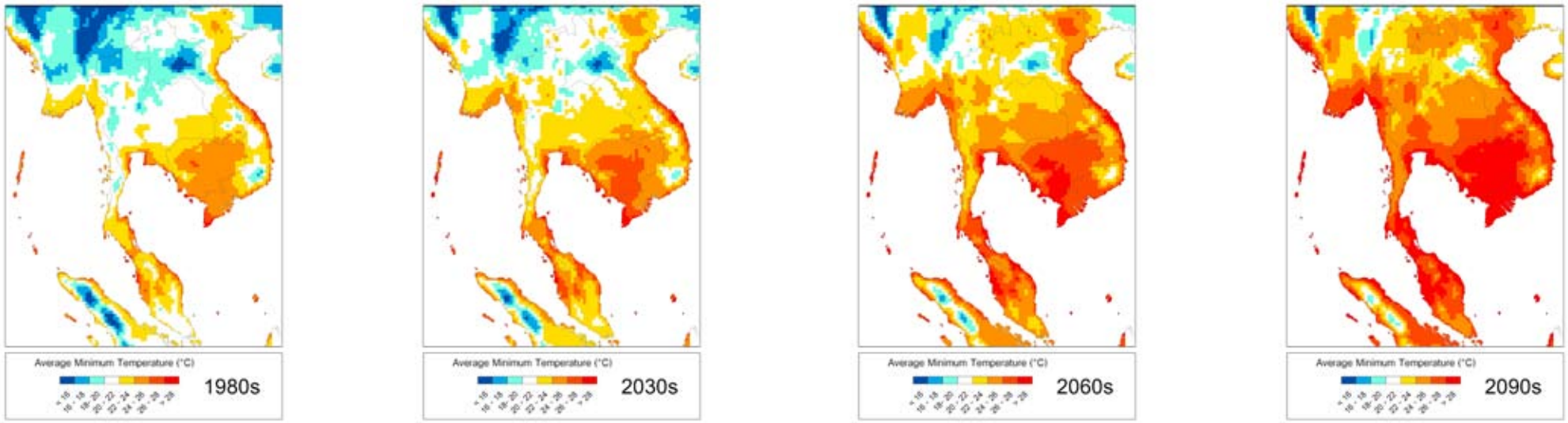
The Greater Mekong region is warming

Average daily temperatures across Southeast Asia have increased 0.5 to 1.5ºC between 1951 and 2000 (IPCC 2007). Thailand's temperatures have reportedly increased 1.0 to 1.8ºC in the past 50 years; average daytime temperatures in the month of April have been particularly high at 40ºC (ADB 2009). Vietnam's temperatures increased by 0.7°C during this same period (ADB 2009). Daily maximum and minimum temperatures are also increasing (TKK & SEA START RC 2009).

As a result, since 1950 the region has seen more hot days and warm nights and fewer cool days and nights (Manton *et al* 2001). These changes in temperature extremes (and other extreme climatic events) are most strongly associated with climate change impacts (Griffiths *et al*. 2005).

By the end of the century, the region is expected to warm another 2-4°C (IPCC 2007, ADB 2009). In the next 20 years, mean temperatures across the Mekong River Basin will most likely increase by 0.79ºC with greater increases in the colder catchments in the north of the basin (Eastham 2008).

Figure 3: Average daily minimum temperature compared to the baseline decade of the 1980s



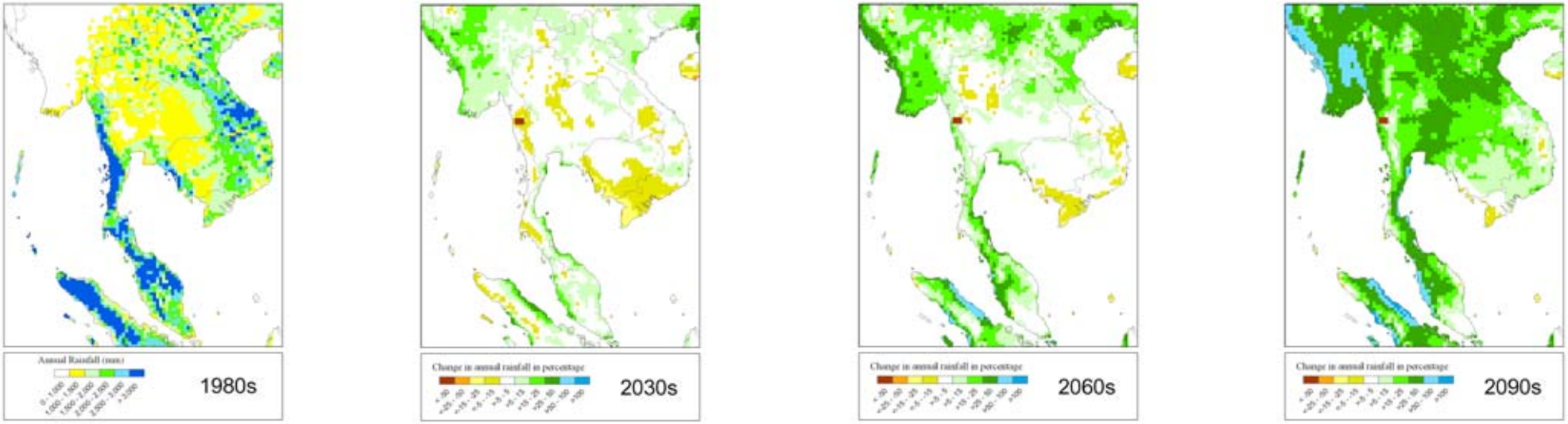
Source: SEA START RC 2009

The Greater Mekong region is getting wetter

Precipitation patterns are quite complex across Southeast Asia owing to the varied terrain and maritime influences (Trenberth *et al* 2007). In the Greater Mekong region from 1961 to 1998, although the number of extreme rainfall events decreased the amount of rain falling during these events increased (Manton *et al* 2001).

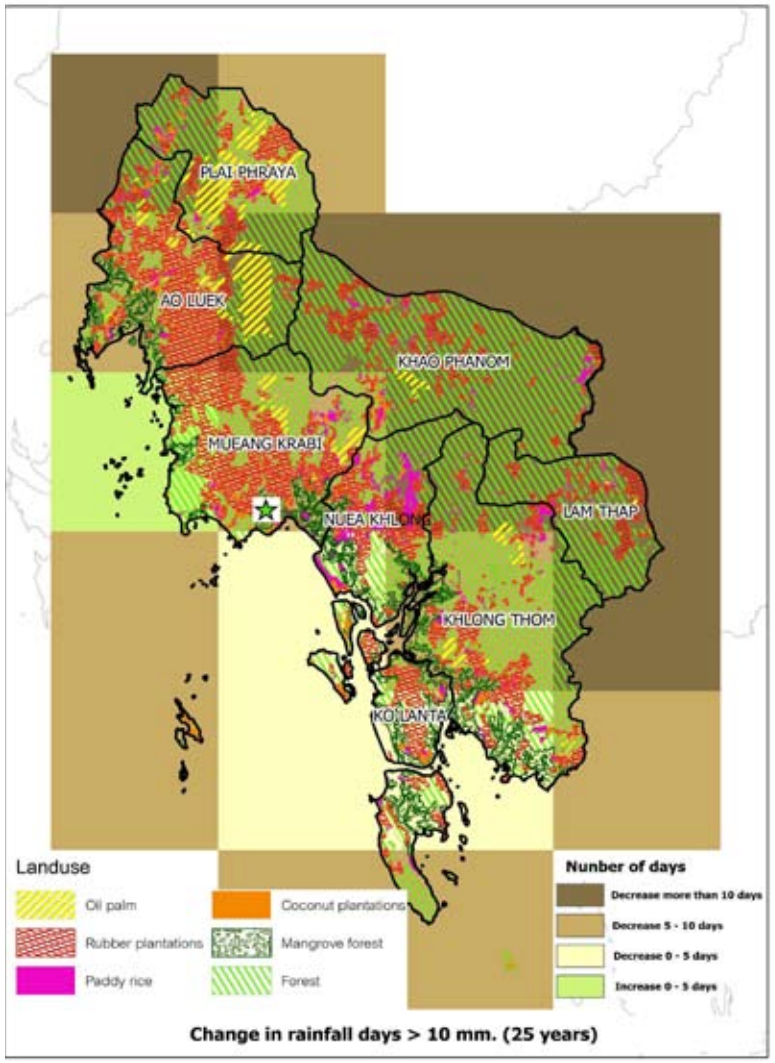
Total annual rainfall will increase by 5-25% across the northern part of the Mekong region in the next few decades and up to 50% across most of the region by the end of the century (Figure 4). The Mekong Delta, which may receive 15% less rainfall throughout the century, is an important exception (Figure 4). Heavier storms during the wet season will account for the regional increase because drier dry seasons are predicted (TKK & SEA START RC 2009). Although the length of the wet season is not expected to change in most of the region, it may contract in some areas, such as Krabi, Thailand, by up to 4 weeks (WWF & SEA START RC 2008).

Figure 4: Average annual rainfall i.e. precipitation (top) and future change in the annual rainfall compared to the baseline decade of 1980s (bottom) under A2 climate scenario.



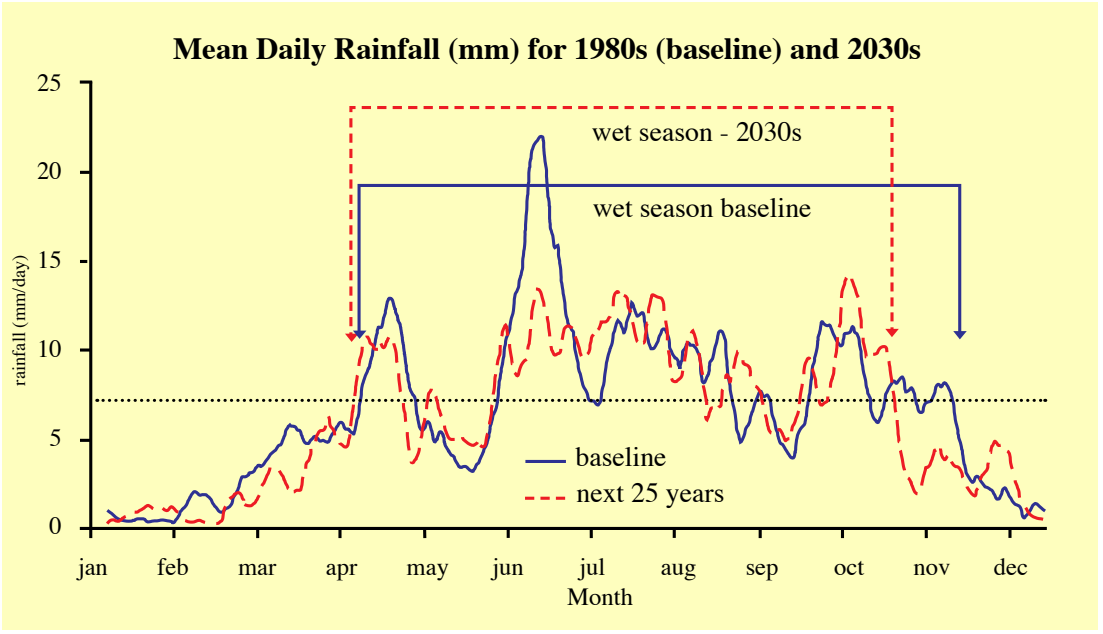
Source: TKK & SEA START RC 2009

Figure 5: Change in the number of rainy days in Krabi, Thailand in 2030s compared to 1980s.



Source: WWF and SEA START RC 2008

Figure 6: Change in the timing and length of the rainy season in Krabi, Thailand 2030s compared to 1990s.



Source: WWF and SEA START RC 2008

The Greater Mekong region is vulnerable to rising sea levels

Climate change has been increasing global sea levels by 1.7 to 1.8 mm per year over the last century, with an increased rate of about 3 mm per year during the last decade (ADB 2008). Many coastal regions are already experiencing the impacts.

The Greater Mekong region is especially at risk because of its extensive coastlines and major deltas that are barely above mean sea level. Even small increases in global sea levels can cause large-scale devastation, when monsoon winds combine with high tides creating storm surges (especially during the typhoon season) leading to greater inundation, as experienced with Typhoon Linda and Cyclone Nargis.

Relative sea level has increased 6 mm per year in the Mekong Delta and 13 to 150 mm per year in the Chao Phraya Delta (Ryvitski *et al*. 2009). Land subsidence from groundwater abstraction and sediment losses from upstream dams are already causing the region's deltas to sink and sea level rise is exacerbating the problem (Ryvitski et al. 2009, see case study in Box 1). Salt-water intrusion and land loss have already affected the lives and livelihoods of people in the coastal areas of Thailand and Vietnam.

By the end of the century, higher sea levels in the Mekong Delta, where nearly half of Vietnam's rice is grown, may inundate about half (~1.4 million ha) of the delta's agricultural lands (Warner *et al*. 2009). A sea level increase of 1 meter would inundate a quarter of Ho Chi Minh City, Vietnam's largest city and home to more than 6 million people.

Box 1. Case study: Losing ground in Khok Kham, Gulf of Thailand.

Climate change does not occur in isolation. It is one of many factors putting pressure on ecosystems and on people's livelihoods. For the last ten years the residents of Khok Kham, in the province of Samut Sakhon have watched the sea eat away a kilometer of land from the coast.

Mr. Vorapol, a 48 year old village chief from Khok Kham district has moved eight times in as many years due to coastal erosion. Today, at high tide his childhood home is fully submerged. Like most people from this area, Mr Vorapol makes a living from prawn farming and agriculture. A loss of land means a loss of their most valuable asset and the source of their livelihoods.

There are a number of reasons why the coast is losing ground to the sea in Samut Sakhon, the location of the province close to Bangkok, where excessive groundwater extraction is causing the land to subside. The construction of dams on the upper reaches of the Chao Phraya and Tha Chin Rivers decrease the flow of sediment to the gulf, weakening its ability to replenish itself. The encroachment of mangroves by shrimp farmers removed the coast's natural protection, reducing its ability to buffer waves and trap sediments. All of these factors reduce ecosystem functions leading to coastal erosion. Climate change makes this situation much worse.

Monsoon winds have intensified as a result of climate change. This means more powerful waves hitting the coast along the Gulf of Thailand. During the monsoon season, in the absence of mangrove forests large amounts of sediment are being washed out to sea, resulting in a net loss of sediment to the sea. Sea level rise exacerbates this problem.

Over the years, the community at Khok Kham has tried different ways to minimize the damage or to adapt to the situation. Often this resulted in short-sighted solutions that provided immediate relief but worsened the problem in the long run or transferred the problem along the coast.

In Khok Kham, one individual has taken the time and effort to search for a long-term solution. Mr. Vorapol knows and understands the region and has been a witness to the escalation of the problem. He realized that the key in ensuring the health of the coast was to restore the mangrove forests.

The model Mr. Vorapol designed involves constructing zigzag shaped bamboo fences parallel to the coast to trap sediment. Rather than stop the water, which solid concrete walls would, they allow the seawater to slowly filter through. This reduction in flow rate allows the sediments to deposit, and this provides a suitable substrate for mangrove saplings to be planted. Within a decade the mangroves are substantial enough to continue to trap sediment and maintain the ecosystem on their own, long after the bamboo fence has disappeared under the waves.

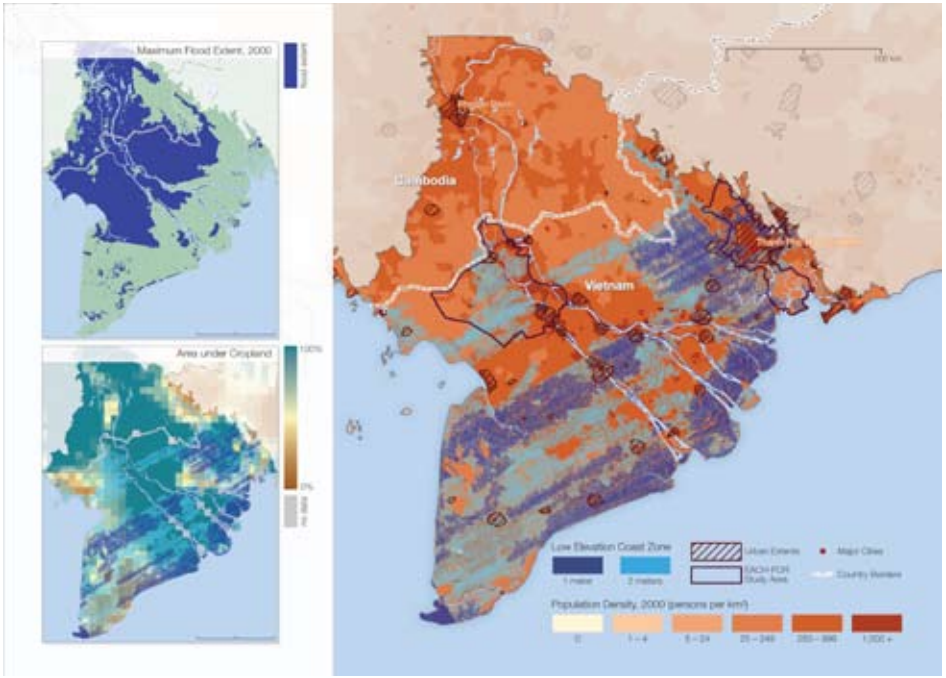
Strategies like this demonstrate that local knowledge and natural materials can bolster ecosystem services, thereby offering better solutions to hard structures or other engineering approaches. The mangrove restoration protects the coast but also creates habitat for myriad small fish and invertebrates the basis of the local food web, thereby supporting the coastal ecosystem and by consequence local fishermen.

Longer and more intense floods, droughts, and storms are occurring

The frequency of extreme weather events has also increased. Heat waves have become more common (IPCC 2007). The number of tropical cyclones was higher during 1990-2003 (IPCC 2007). With its long coastline and location in the midst of the northwest Pacific Ocean's typhoon belt, the UNDP considers Vietnam to be one of the 10 countries worldwide most at risk to tropical cyclones (Chaudhry and Ruysschaert 2007). In the past 40 years, Vietnam has experienced fewer, but more intense storms (Niemnil *et al* 2008).

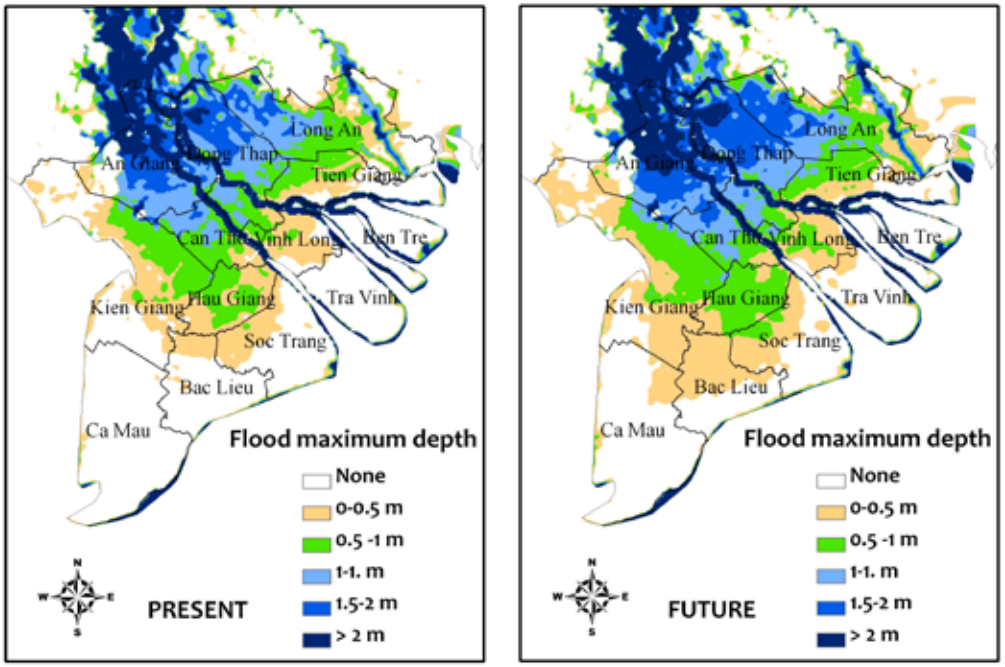
In 2000, unusually widespread monsoon floods deluged nearly 800,000 km2 of Thailand, Laos Cambodia, and Vietnam including extensive areas of the Mekong Delta (Figure 7). In the next 20-30 years, floods in the Mekong Delta will likely inundate more land at greater depths (Figure 8). They may also arrive earlier or later depending changes in peak flow and precipitation patterns in the region.

Figure 7: The Mekong Delta: Flood extent (2000)



Source: (Warner et al. 2009)

Figure 8: Estimated change in the flooded area in the Mekong Delta in the future (right), compared to the present day (left).



Source: TKK & SEA START RC 2009.

Glaciers feeding the Mekong's headwaters are disappearing

Glaciers around the globe, including those in the Tibetan plateau forming the Mekong's headwaters, are receding because of warmer temperatures. Loss of these glaciers will cause major impacts on the hydrology and freshwater availability in other large basins in Asia. In the Mekong Basin, however, the impacts on flow in the lower basin are expected to be modest because the area and volume of glaciers is relatively small (Eastham 2008) and because glacial melt contributes only 6.6% of the total discharge (Xu 2008). The impacts on sediment load and ecology of the high altitude wetlands in the upper basin are poorly understood, but could be significant (see Box 2).

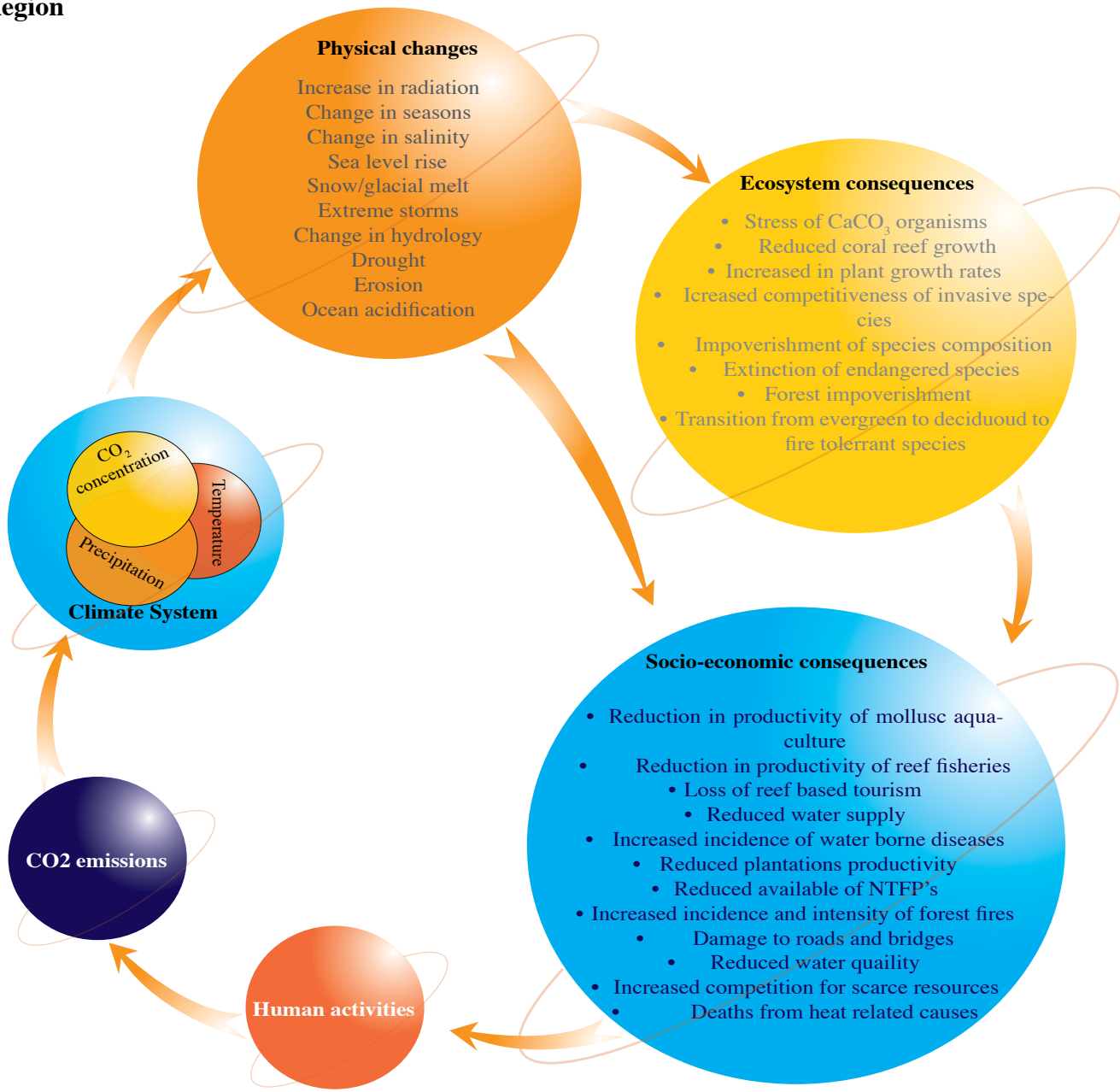
Box 2: The high-altitude wetlands of the upper Mekong face an uncertain future.

The upper Mekong Basin situated in the Tibetan Plateau is also highly vulnerable to climate change. In the 40 years from 1955 to 1996 average temperatures on the Tibetan Plateau increased by 0.64ºC. By the 2050s, the region will warm an additional 2-2.7ºC above 1990 levels (Wilkes 2008). Highland glaciers, ice, and snow, which represent major natural reservoirs of frozen water, feed high altitude wetlands and nine of Asia's great rivers, including the Mekong, Irrawaddy and Salween (Xu 2008). These natural high altitude wetlands serve as a buffer to local climate variation. They compensate for the deficit of rainfall and snowmelt during dry years and store water from cloudy skies to reduce melting during wet years. High-altitude wetlands are important elements in conservation and water management at regional, national and international levels.

Escalating Impacts in the Greater Mekong Region

Climate change is already causing ecological and socio-economic impacts in the Greater Mekong region (Figure 9). The increasing frequency and intensity of extreme weather events such as droughts, floods, and typhoons are affecting the production of grains, fish supply and forests. The quality and quantity of water resources is shifting. Conditions favouring the spread of invasive species and the spread of diseases such as malaria and dengue fever are becoming more prevalent. The region is struggling against the loss of its arable lands and coastal areas due to a rise in sea levels, more frequent storm surges, heightened coastal erosion, and soil and groundwater salinisation. The people of the Mekong are expected to face severe food insecurity if the Asian monsoon system is substantially changed. All of these factors will require people to move from their homes and necessitate the adoption of alternative livelihoods. All of these impacts will worsen as the planet warms. A warmer climate may unleash billons of tonnes of planet-warming methane from melting permafrost in the Tibetan plateau and CO2 from forests increasingly exposed to droughts, insect damage and fires, further exacerbating the problem.

Figure 9: Ecosystem and socio-economic consequences of Climate Change in the Greater Mekong Region



EOLOGICAL IMPACTS

The Greater Mekong: A bastion of biodiversity

The Greater Mekong region is one of the most biologically diverse places on Earth. Sixteen of WWF's Global 200 ecoregions, critical landscapes of international biological importance, can be found here. Growing pressures resulting from unsustainable and uncoordinated development threaten these important habitats. These threats include forest conversion for agricultural plantations, unsustainable logging and illegal timber trade, wildlife trade, overfishing, dam and road construction, and mining. The Greater Mekong is expected to be among the most vulnerable to climate change, which will amplify the impacts of existing threats to the region's terrestrial, freshwater, estuarine and marine ecosystems (WWF 2009).

The Greater Mekong region is home to a diversity of landscapes such as the Greater Annamites, the Lower Mekong Dry Forests, and the Kayeh Karen Tenasserim Ecoregions (KKTE). All three areas boast a high diversity of plant and animal species and are important because they harbour many rare, endemic, and endangered species. For example, the relatively intact and contiguous hill and montane forests of the KKTE are home to two of Asia's most endangered species, the tiger and the Asian elephant.

Given the unique and important biodiversity of the Greater Annamites, including 256 types of mammals and 910 species of birds, the governments of Vietnam and Laos have established 50 protected areas covering 93,700 km2, which is home to 37 million people and 30 different ethnic groups. The persistence of the Greater Annamites forests and associate wildlife through major changes in climate over geological time has resulted in the high levels of endemism found in the region (Baltzer *et al* 2001). However, these centres of biodiversity that were buffered from previous changes in climate will probably not serve as future refugia because the rare habitats that support the diversity will likely shrink under predicted climate change (Ohlemuller *et al* 2008). Moreover, climate change in the past was not concurrent with other pressures and changes (e.g., land use change, invasive species, unsustainable harvesting practices, and hunting), which have reduced the buffering capacity of these forests. Thus, the rapid pace of economic development in and surrounding the forest will alter their integrity to such an extent that they are no longer buffered from climate change or no longer resilient to its impacts. Furthermore, the impact on the forests of the projected 8.5 to 20 million people who could be displaced from coastal Vietnam as a result of sea level rise during the next century is a major concern (Dasgupta *et al* 2007, Carew-Reid 2008).

Climate change is expected to directly affect biodiversity by causing shifts in species distributions with potentially major effects on ecosystem structure, composition and processes (Williams *et al* 2007). These shifts in distribution will vary by species. Although some species will be able to adapt without dispersing (Bradshaw *et al* 2006), many will not, potentially resulting in massive extinctions (Stork *et al* 2007). In the Indo-Burma biological hotspot (which roughly coincides with the Greater Mekong Region) it was estimated that 133 to 2,835 plant species and 10 to 213 vertebrate species could become extinct (Malcolm *et al* 2006). The direct impacts of climate change will depend on the sensitivity of individual species and ecological processes (e.g., rates of photosynthesis, pollination, seed dispersal, and migration) to changes in temperature and precipitation. Changes in forest composition will influence the animals found in the forest. The fact that these are home to many endemic and rare species (e.g. Asian elephant, tiger, douc langur, gaur, banteng, Eld's deer, serow, clouded leopard, pygmy, loris, imperial pheasant and Edwards's pheasant) suggests that they will be extremely vulnerable to changes in climate.

In addition, Trisurat *et al* (2009) found that along with significant impacts on the distribution of species in Northern Thailand, the composition of habitats changed. They found that 10 plant species would be categorised as near threatened and lose their habitats. The study also concluded that because deciduous tree species are more resistant to climate change than evergreen tree species, evergreen species will be replaced by deciduous species in the forest. This is because deciduous species are likely to outperform neighbouring evergreen species in a drier climate due to their more efficient water use making them drought-tolerant (Trisurat *et al* 2009). However even the deciduous forest will not escape unaltered. The greater number of hot days and rising temperatures will modify the rich dry forest mosaic reducing the evergreen patches, seasonal wetlands, and isolated ponds, which are important water sources and refugia in the hot season. In addition, with the drier climate the dry forests will face increased incidence of forest fire.

The conclusion is troubling if nothing is done: many species face extinction. However, with concerted actions to keep ecosystems as healthy as possible and reduce non-climate threats, these rare and endemic species and important forest habitats can be conserved and restored. Maintaining and restoring healthy ecosystems maximizes resilience to climate change impacts and offers the best hope for future generations.

The Mighty Mekong: The Region's Water Storehouse

The Mekong River is one of the greatest river systems on Earth and the largest in Southeast Asia. The Mekong River Basin is home to over 65 million people who rely on the river's rich resources for their livelihoods. The Mekong descends from the Tibetan plateau and passes through deep gorges in the upper reaches of Yunnan province in China. The river moves through or forms the borders of Burma, Thailand, and Laos before entering into Cambodia. The Mekong then enters a mega delta in Cambodia and southern Vietnam before emptying into the South China Sea.

The Mekong's distinctive flood-pulse hydrology is unique. During the southwest monsoon, from May to September, the swollen Mekong causes the Tonle Sap River in Cambodia to reverse flow, which in turn, causes a six-fold increase in the area and a 38-fold increase in the volume of the Tonle Sap Lake (Kummu *et al*. 2008). This annual flood pulse drives ecosystem productivity in the Mekong floodplain and Tonle Sap area (Lamberts and Koponen 2008).

The Mekong is among the most biologically rich and diverse river systems on Earth (Cruz et al. 2007)

The Mekong River has one of the most productive inland fisheries in the world with a commercial value of about US$ 3 billion per annum (MRC 2009). A study by IUCN, IWMI, RAMSAR and WRI (2003) suggests that the Mekong Basin supports more fish species (at least 1,300) per unit area than the Amazon. Also more large fish species inhabit the Mekong than any other freshwater ecosystem on the planet. This rich biodiversity is fundamental to the viability of natural resource-based rural livelihoods of the people living along the river banks. These people rely on fisheries as their main source of animal protein and micronutrients and this resource contributes significantly to household income.

The Mekong is one of 9 large river basins in the world that will be sensitive to climate change, and the hydrological effects over the next century will be greater than changes the river has experienced due to climate variability during the last 9000 years. (Aerts et al 2006).

The combination of climate change, non-climate pressures, and potential responses to climate change make the Mekong River Basin's ecosystems and people highly vulnerable. Climate change is likely to exacerbate the impacts caused by existing non-climate threats including, hydropower development, expansion of irrigation, and water diversions. Rainy season storms combined with sea level rise and wind driven waves may cause extensive flooding in the lower basin (Keskinen 2008, Penny 2008).

The Mekong Delta, in particular, is considered one of the three most vulnerable deltas in the world to climate change (Parry *et al*. 2007, Dasgupta 2007) because of the millions of people who will be affected by these impacts and because of its importance for rice production. Changes in the patterns and magnitude of the Mekong's floods as well as changes in salinity due to rising seas threaten the rice, fish and fruit industries (Jacobs 1996, Kakonen 2008). In addition, a 1 m sea level rise would inundate 9 key biodiversity areas in the Mekong delta (Figure 10, Carew-Reid 2008).

Figure 10: A 1 meter sea level rise would inundate and negatively affect 9 key biodiversity areas in the Mekong Delta

Source: Carew-Reid 2008

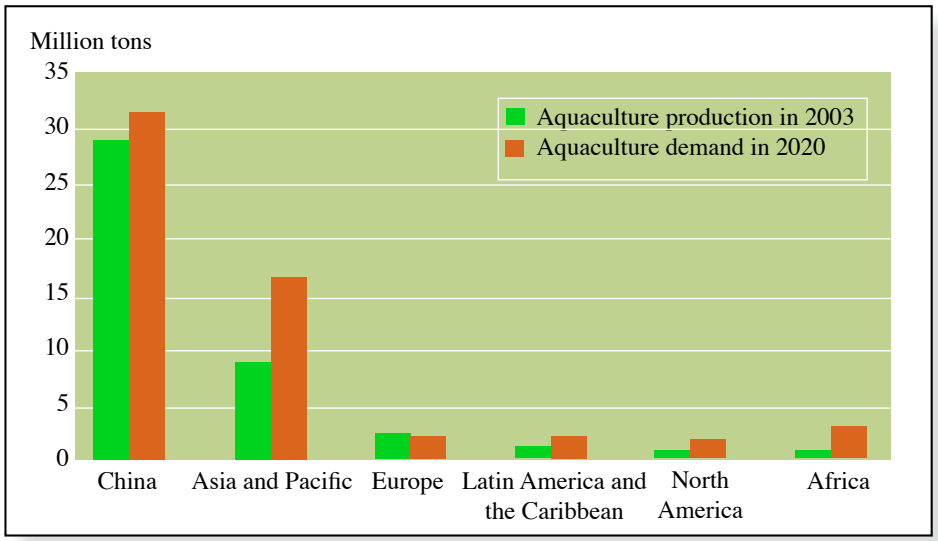
Box 3: Vietnam faces severe impacts from climate change.

Vietnam has enjoyed one of the best development records in recent years of any country in the world. It is one of the few countries on track to meet most of its Millennium Development Goals by 2015. It reduced its poverty rate from about 58 per cent of the population in 1993 to 18 per cent in 2006. Such impressive achievements are now at risk with Vietnam considered to be one of the world's most vulnerable countries to climate change. Gradual changes in sea level rise and higher temperatures, more extreme weather events such as drought, and more intense typhoons are all on the horizon and will have a potentially devastating impact on the country's people and economy.

Source: Oxfam (2008)

Climate change is expected to impact aquatic ecosystems, and alter the distribution and production of fish. Fish migration routes, spawning and feeding grounds, and fishing seasons are all likely to change, and the impacts on fishing communities are uncertain. Inland fisheries are particularly vulnerable to changes in hydrology and water chemistry profoundly affecting the aquatic species upon which these industries depend, and may even "rupture the underlying processes supporting … [Tonle Sap] lake's biodiversity" (Penny 2008, p. 164). The projected Climate change is expected to impact aquatic ecosystems, and alter the distribution and production of fish. Fish migration routes, spawning and feeding grounds, and fishing seasons are all likely to change, and the impacts on fishing communities are uncertain. Inland fisheries are particularly vulnerable to changes in hydrology and water chemistry profoundly affecting the aquatic species upon which these industries depend, and may even "rupture the underlying processes supporting … [Tonle Sap] lake's biodiversity" (Penny 2008, p. 164). The projected increases in weather events bring increased risks to coastal fishing communities and aquaculture systems (WorldFish Center 2008). Demand for fish from aquaculture is projected to increase (Figure 11), but climate change is expected to negatively affect aquaculture operations worldwide. Rising seas, more severe storms, and saltwater intrusion in the deltas will damage the region's aquaculture industry, which is based on species with limited saline tolerance, such as catfish in the Mekong Delta. A recent survey of climate change impacts on fisheries in 130 countries concluded that Cambodia and Vietnam are among the most vulnerable because of their heavy dependence on fisheries, high exposure to climate risks, and limited coping capacity (Allison *et al*. 2009).

Figure 11: Demand for fish from aquaculture will increase, particularly in Asia and Africa



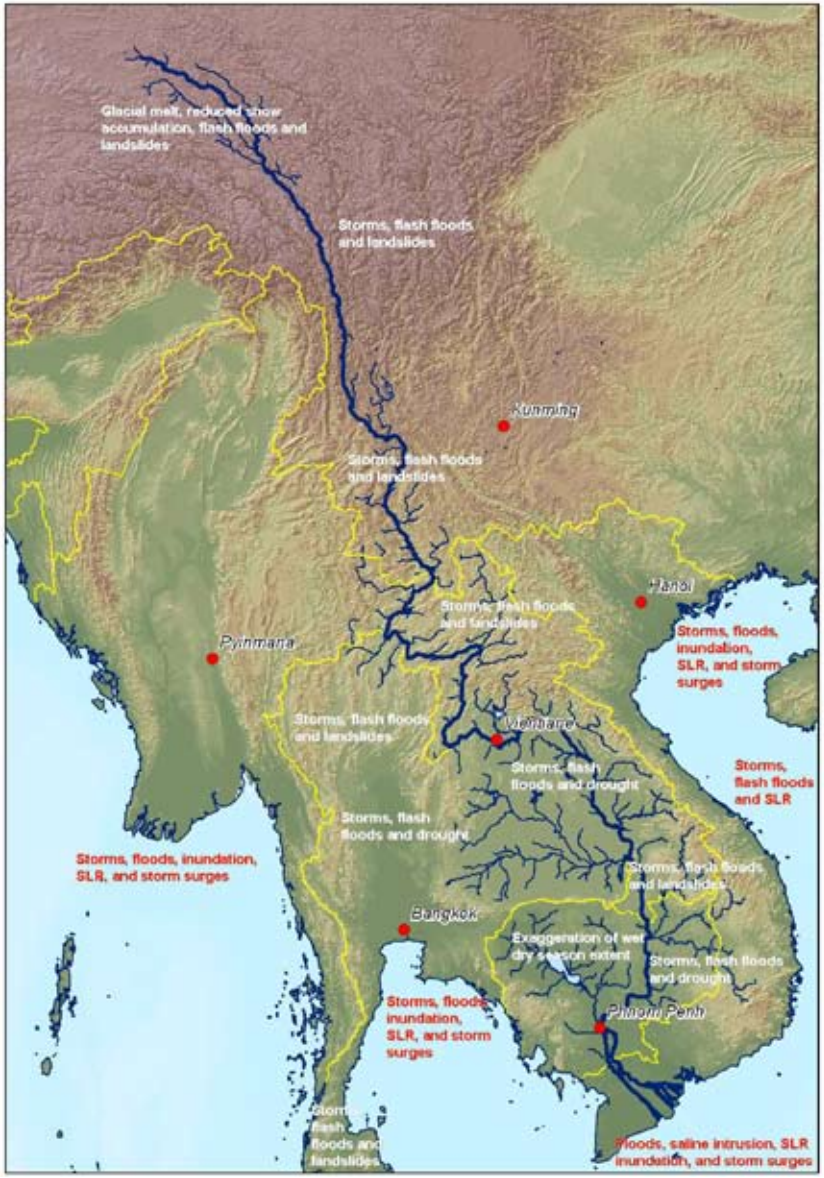
Source (WB 2009 / De Silva and Soto 2009)

The rice bowl of Asia will be severely impacted

Agriculture is one of the Greater Mekong region's most important sectors for livelihoods, food security and national economies (WWF 2008a). Agriculture also accounts for the largest proportion of water abstracted from rivers and underground aquifers (ADB 2009). Rice is by far the region's most important crop; for example, rice is grown on 88% of Thailand's and 94% of Lao PDR's land used for cereal production (Chinvanno *et al* 2008). The Mekong Delta supports about half of Vietnam's yearly rice production. It also produces 60% of Vietnam's fish-shrimp harvest and 80% of the fruit crop (Warner *et al*. 2009). Thailand and Vietnam are the world's first and second largest rice exporters. This year, Vietnam exported a record volume of 7 million tonnes of rice (Reuters 2009). Most of the cultivated rice depends on rain (vs. irrigation) for production. Climate change will impact agriculture in many different ways and this sector is considered very sensitive due to substantial impacts expected on livelihoods, food security, economy, trade and stability (Sivakumar *et al* 2005).

With the expected long-term changes in rainfall patterns and increasing temperatures coupled with an onslaught of natural disasters, climate change is expected to significantly affect the Greater Mekong Region's agricultural productivity. Although annual flooding of the paddy fields is required for the rice crop to succeed, unusually heavy flooding or severe droughts cause farmers to lose their entire crop and cut access to markets and possible coping strategies, through damage to infrastructure (TKK & SEA START RC. 2009). Figure 12 depicts a map of the region showing the likely impacts of climate change this century. This will have a major impact on the region's food security and affect economic growth. A modest (3.6%) increase in agricultural productivity is possible in the region, but overall food scarcity is also expected to increase (MRC 2009). Wheat will likely be sensitive to increases in maximum temperature whereas rice will likely be sensitive to increases in minimum temperatures (Sivakumar *et al* 2005).

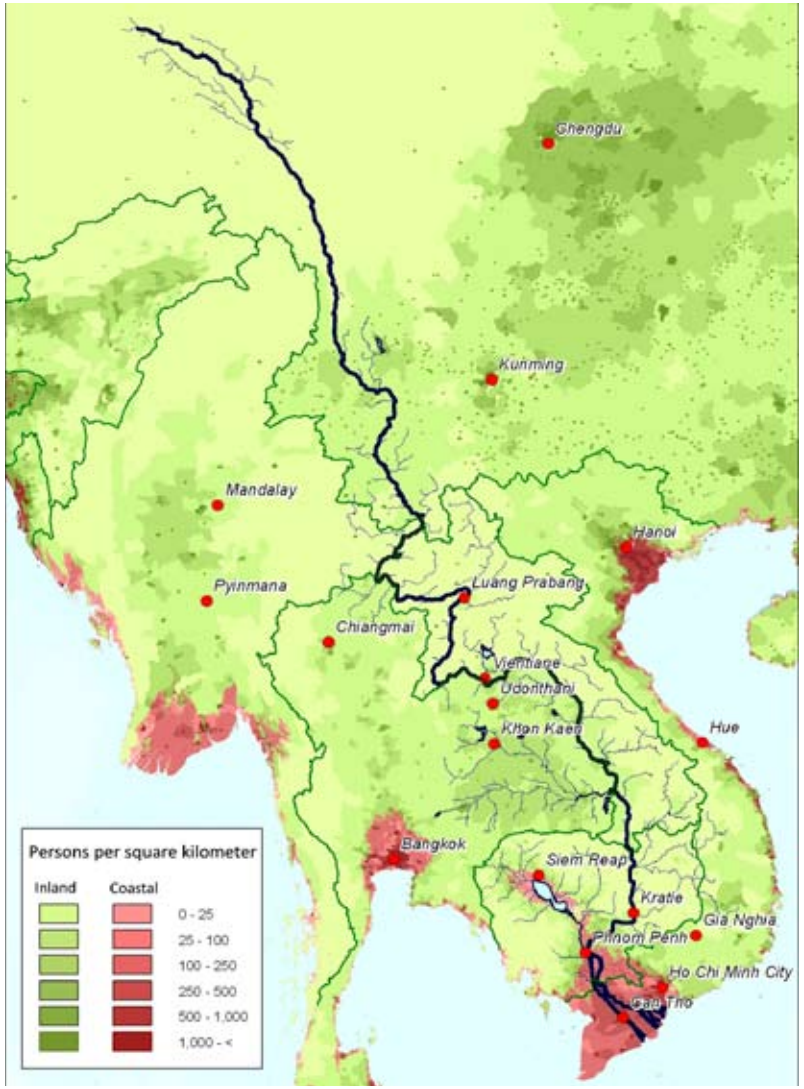
Figure 12: Map of region showing likely impacts of climatechanges this century



PEOPLE, COMMUNITIES, AND ECONOMIES AT RISK

The Greater Mekong Region's economy is intrinsically linked to its natural resource base, and as a consequence any changes will have lasting impacts on the people of the region. As the resilience of many ecosystems is likely to be exceeded this century by unprecedented combinations of climate change impacts (e.g. flooding, droughts) and other global change drivers (land use change, pollution, fragmentation of natural systems, overexploitation of resources), many vulnerable people and economic sectors, generally those located in the coastal areas and on the floodplains of major rivers will be most vulnerable to change (see Figure 13). Farmers who are directly dependent on agriculture for their livelihoods are especially vulnerable when extreme events such as floods or droughts occur unpredictably or at the wrong time of the cropping cycle, destroying their entire crop. According to one Vietnamese migrant worker, "Disasters occurred so often – my family lost the crop, my family had to borrow money to spend. Now, my family is not able to pay off the loan so I have to come here to work to help my family to pay the loan" (Warner *et al*. 2009)[1].

Figure 13. Population density in the Greater Mekong Region. Large human populations living in low-lying coastal areas and floodplains make the region highly vulnerable to floods, saltwater intrusion, and rising sea levels



Source: WWF

[1] This is an example of one family who migrated elsewhere in search of an alternative livelihood.

Urban communities are not spared from the impacts of climate change. The rapid urbanisation and spread of suburbs increase the vulnerability of cities such as Bangkok and Ho Chi Minh City to climate change impacts. As mega cities and their suburbs expand into rice fields and wetlands, the water retention capacity of the surrounding landscape is lost resulting in increasingly severe floods. Furthermore, cities such as Bangkok are experiencing a number of threats, which could lead to economic repercussions for the country. In 2005, Bangkok emitted as much CO2 as London and more than Toronto. The city is significantly prone to flooding and suffers from land subsidence caused by over-pumping of groundwater. Each year, parts of Bangkok sink by 5-10 mm and by as much as 30 mm in outlying areas (UNEP 2009).

Out-migration and displacement of peoples are already occurring

Although economic and political factors are the dominant drivers of displacement and migration today, climate change is already having a detectable effect (Warner *et al*. 2009). Although the exact number of people that will be on the move by mid-century is uncertain, the scope and scale could vastly exceed anything that has occurred before. People living in low-lying areas will be the first and most severely affected. In the Greater Mekong region, with many people dependent on ecosystems for their livelihoods, the negative climate effects on these ecosystems will become the primary driver of migration during the next two to three decades (Warner *et al*. 2009).

In the future, one out of every ten Vietnamese may face displacement by sea level rise in the Mekong Delta. (Source: Warner et al. 2009 based on Dasgupta 2007)

The maps depicted in Figure 14 indicate that many people living in the Mekong Delta are at risk and at some point will almost certainly move elsewhere. Where and when they will move is unclear. This uncertainty creates the potential for social conflict and perhaps even international security concerns (Campbell *et al*. 2007, Warner *et al*. 2009). Large-scale migrations may also place additional stress on areas designated for biodiversity conservation.

Environmentally-induced migration and displacement has the potential to become an unprecedented phenomenon—both in terms of scale and scope. Its effects on the global economy, international development, and national budgets could have significant implications for almost all dimensions of human security and wellbeing, in addition to political and state security (Warner et al. 2009).

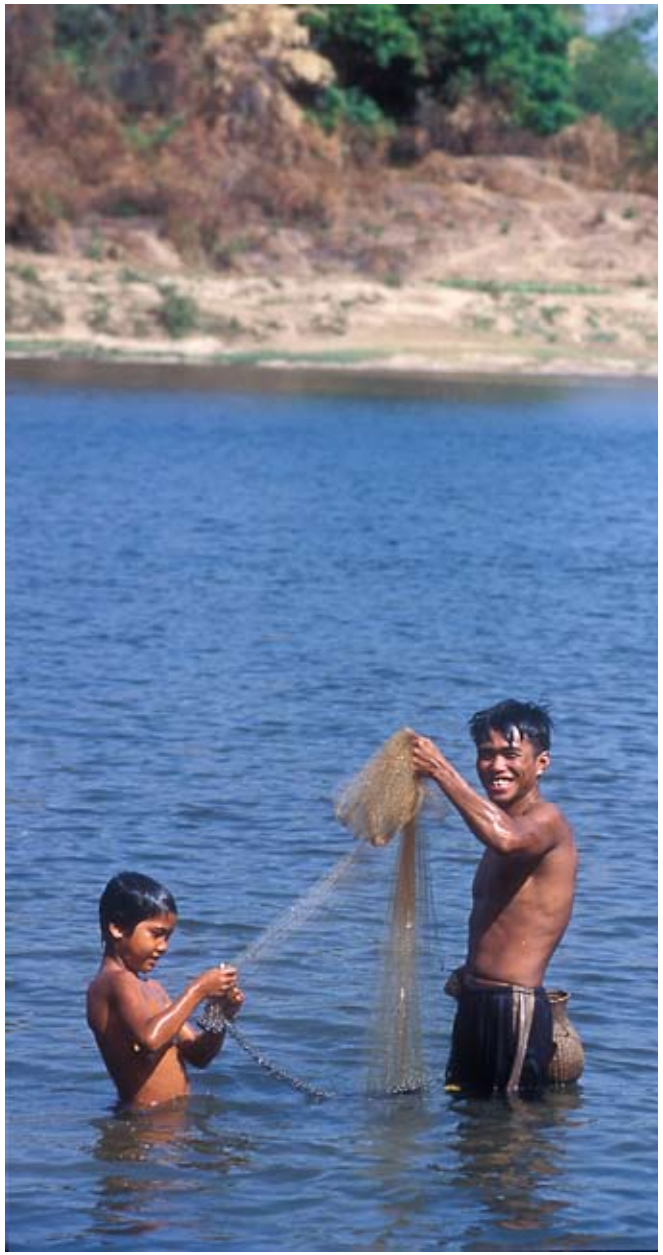
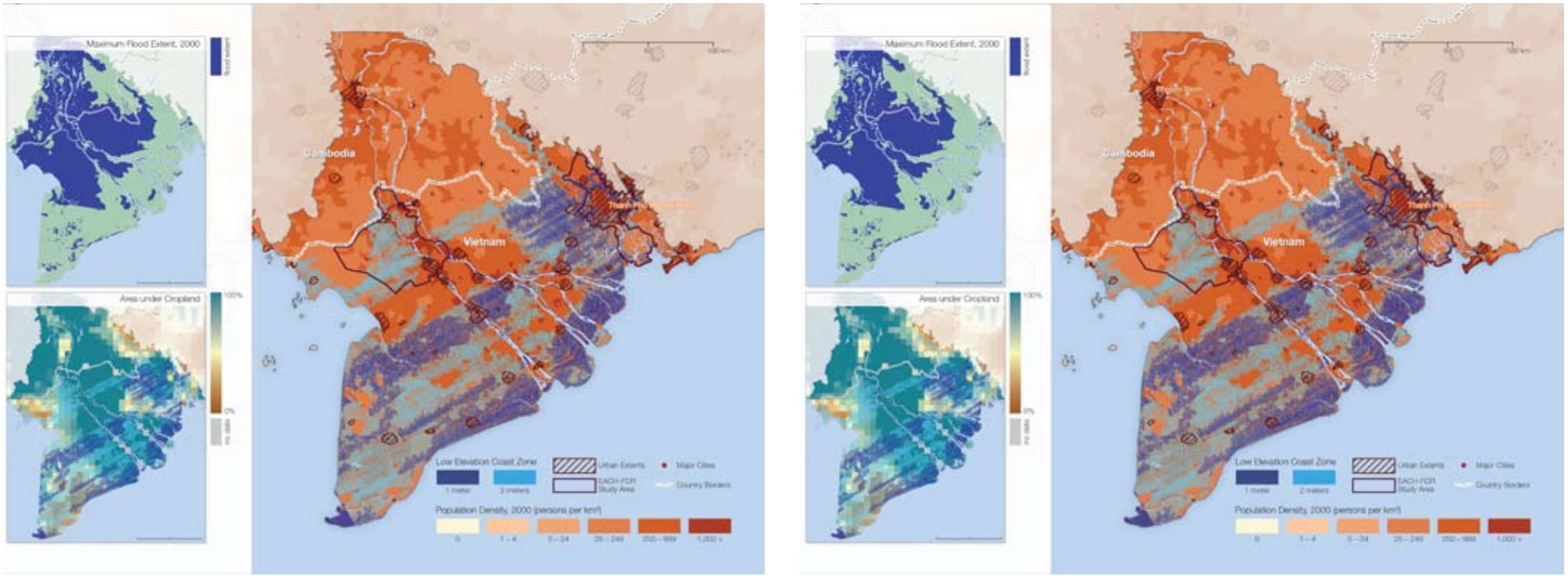


Figure 14: Mekong Delta depicting 1 meter sea level rise on a population density map (left) and Distribution of agricultural lands (right)



Source: Warner et al. 2009, courtesy of CARE International and CIESIN at the Earth Institute of Columbia University

CONCLUSION: URGENT ACTION NOW

This report paints a picture of an important biological hotspot that is slated for major changes in the future if the onslaught of climate change is not addressed in a coordinated and integrated way. The decisions taken today will forever impact the ecosystems and livelihood resources of the region. Failure to act on climate change now will lead to regrettable and potentially catastrophic consequences.

"Solutions to the problems of climate change should be sought within the framework of sustainable development in an integrated, coordinated and mutually reinforced manner."
Dr Thongloun Sisoulith, Lao PDR Deputy Prime Minister and Minister of Foreign Affairs, Quote from Vientiane Times 24/9/09.

The fundamental challenge facing the Greater Mekong Region's governments is clear: how to maintain the region's resilience in the face of potentially catastrophic climate change, even as development continues. The region's governments and people need to identify a way to sustainably develop their economies, alleviate poverty, and conserve the region's extraordinary species and ecosystems. This challenge is not insurmountable, but early and effective measures must be put in place to ensure that the ecological systems, products, and services upon which the development of this region fundamentally depends are not degraded or irreversibly lost. Improved environmental management and more effective conservation will maximize the region's capacity to adapt to and reduce the unavoidable climate change impacts. Broad commitments to address climate change should be agreed at a regional level to ensure that the actions of one country do not negatively affect or undermine the efforts of their neighbours.

Partnerships and capacity at all levels are needed to address climate change in a holistic manner that incorporates both adaptation and mitigation and draws upon the region's vast biological and human resources. National governments will need to embrace regional strategies, such as investments in renewable energy and energy efficiency technologies that will help erase both economic and ecological deficits, whilst growing economies in a green way. Environmental values should not been seen as impediments to economic progress. They should instead be seen as opportunities for a transformation to a truly sustainable future for the region.

Finally, the region will need to "prepare for scenarios where impacts exceed adaptation capacity. If emissions continue on a 'business as usual' trajectory and don't peak and decline well before 2020 and pre-emptive adaptation measures are not implemented, adaptation will cease to be a viable option for many of the most vulnerable states, communities and ecosystems. Negotiators need to think beyond the present adaptation discourse and consider insurance set-ups, some form of financial mechanisms for refugees or other devastated groups or other forms for the most affected by irrevocable impacts" (WWF 2008b).

Failure to act to reduce these threats will ultimately spell out a gloomy economic and social future for the Greater Mekong and its people.

This report urges the peoples and governments of the Greater Mekong region to take decisive action to avert a major crisis in the coming years. The combined threats of poverty, financial instability, and climate change need to be met with effective adaptation strategies that provide insurance and maximise resilience in the face of future uncertainties while taking account of changing conditions. WWF believes that the recommendations below, if effectively implemented, will maintain or enhance the region's adaptation potential.

ADOPT ASIA'S FIRST REGIONAL CLIMATE CHANGE ADAPTATION AGREEMENT

An essential first task to address climate change is for the governments of the Greater Mekong region to adopt a joint adaptation agreement. This agreement would serve as an enabling regional framework for the recommendations below to be coordinated and implemented.

The growth of the Greater Mekong region has been paid for by the exploitation of its natural wealth. Recent poverty reduction and other economic achievements across the region are being threatened by climate change. Therefore, a regional mechanism to cooperate on climate change adaptation should be a high priority for the governments of the region. Such an agreement would focus on existing conservation and development priorities by incorporating climate change adaptation in existing development plans and their implementation. This agreement would provide a platform for the equitable transboundary management of shared natural resources and of high conservation value areas. In the case where transboundary conflicts arise, the agreement would provide a regional platform for discussion and resolution, with clear directions on compensation sealed in the agreement. In addition, such an agreement will allow for adaptation to be scaled up across the region, with the adaptation choices of one country complementing not conflicting with the adaptation actions of their neighbours. This regional political cooperation would strengthen investor confidence and help to ensure secure and predictable financial support for adaptation can be delivered through well-governed, effective, and equitable funding mechanisms.

STRENGTHEN EXISTING GOVERNANCE STRUCTURES AND ENSURE PARTICIPATION OF ALL STAKEHOLDERS IN ADDRESSING CLIMATE CHANGE

Existing governance structures in the Greater Mekong region need to be strengthened in order to ensure that climate change activities are developed and managed in an effective and participatory manner. Adaptation plans cannot be developed on a sector-by sector basis. Adaptation must be mainstreamed into development and conservation planning. If not done in an integrated manner, problems will be created such as adaptation being effective against one issue but maladaptive against another. Coordination is essential. It will be important to plan holistically and to ensure that governance structures support, implement and monitor these issues. Furthermore, climate change planning, both adaptation and mitigation, will require the education of current and future leaders and practitioners. Mechanisms must be created for training to build capacity on climate change along with determining how to integrate climate change into all stages and levels of planning.

Participatory stakeholder engagement in climate change governance is vital. Many actors are now involved in determining ways to address climate change in the region. These include research, adaptation and mitigation activities, pilot studies, and capacity building, among others. Using a multi-stakeholder process across all levels of decision making and involving local people and communities in planning will ensure effective solutions for social and ecological systems within the Greater Mekong region. Local knowledge will help generate innovative and effective adaptation strategies and reduce the influence of local stress factors on coastal, freshwater and terrestrial ecosystems making them better able to survive climate change impacts. The region's governments along with donors, NGOs and other international organisations need to jointly develop a process of coordination of stakeholders and sharing of information.

ACT NOW TO USE EXISTING KNOWLEDGE TO ADDRESS CLIMATE CHANGE

There are already scores of reports and documents that significantly contribute to the growing knowledge base on climate change in the Greater Mekong region. Whist not perfect, a great deal of information already exists. This information must be acted upon and can be done through improved governance structures to nurture adaptive management frameworks to allow for changes to be incorporated as more knowledge is gained. In addition to the governance structures, there are numerous national and regional initiatives that are providing platforms to discuss current and new knowledge such as the UNEP/SENSA/SEI knowledge platform on climate change, Mekong River Commission Climate Change Adaptation Initiative, the M-POWER governance network, the Southeast Asian Regional Center of the Global Change System for Analysis,

Research, and Training (SEA START RC), the DRAGON Institute, among others. These knowledge platforms can help resource managers to improve their monitoring systems to contribute to a more accurate understanding of climate change in the Greater Mekong region

EMPHASISE ECOSYSTEM-BASED ADAPTATION APPROACHES THAT MAINTAIN THE RESILIENCE OF THE REGION

Adaptation approaches should focus on maintaining or restoring the diverse ecosystems of the Greater Mekong. The health of these ecosystems and the products and services they provide, offer the most effective and least costly adaptation solution, that benefits the largest proportion of the regions population. Ecosystem-based adaptation approaches that conserve biodiversity and sequester carbon while reducing the vulnerability of people and their livelihoods to climate change impacts are already being promoted. Such ecosystem-based adaptations should be further mainstreamed into national and regional strategies including NAPAs (National Adaptation Programmes of Action). Ecosystem-based approaches to climate change will increase the resilience of natural systems and are based on existing practices and local knowledge. These offer long-term solutions that are more feasible than engineering options that rely heavily on technical capacity, routine maintenance and large-scale infrastructure. Ecosystem-based approaches also protect future options for development whereas hard, engineering solutions may foreclose future options if they degrade ecosystems or divert impacts to another location.

INCLUDE MITIGATION IN ADAPTATION STRATEGIES

Mitigation refers to efforts to reduce GHG emissions and to the enhancement of sinks (i.e., carbon sequestration). Afforestation, reforestation, and capturing and storing carbon from energy production and industrial processes are examples of carbon sequestration strategies. Energy conservation and switching to C-neutral renewable fuels are examples of reducing GHG emissions. Protecting, maintaining, and sustainably managing standing forests sequester carbon and reduce GHG emissions. Although the Greater Mekong region is rapidly developing, there is still a window of opportunity to promote these mitigation options. However these should not be treated separately from adaptation strategies. In fact, forest protection and management is both a mitigation strategy and an ecosystem-based adaptation that can maintain the region's resilience to climate change. Climate change is a symptom of unsustainable development as much as a driver of change. If reducing emissions from deforestation and degradation (REDD) becomes an accepted strategy by the UN Framework Convention on Climate Change (UNFCCC), there should be excellent opportunities for the region to benefit from the synergy of adaptation with mitigation.

ENSURE ADEQUATE RESOURCES ARE AVAILABLE FOR ADAPTATION INITIATIVES

The Greater Mekong region should enhance institutional capacity to make better use of existing budgets to compliment potential international funding and investment sources. Existing funding sources provide initial support and can be a catalyst for raising co-financing. The Mekong region has not yet made full use of these funding resources, for example regional representation in the global carbon market is still limited. Both domestic and international commitments need to be made and this should be a priority in Copenhagen in December 2009.

"As a country that emits a relatively negligible level of greenhouse gases, we are nonetheless committed to playing a part in the global effort to address climate change,"

Dr Thongloun Sisoulith, Lao PDR Deputy Prime Minister and Minister of Foreign Affairs, Quote from Vientiane Times 24/9/09.

In addition to these actions to increase the region's resilience, WWF urges the governments of the Greater Mekong region to help **forge the strongest possible international agreement to slow the rate and extent of climate change.** Limiting global warming to less than 2˚C above pre-industrial temperatures by 2100 will help avoid the worst impacts of climate change. Achieving this goal will require steep and immediate cuts in global GHG emissions. By 2020, global GHG emissions must be 30-40% below 1990 levels. By 2050 global emissions must be 80% below 1990 levels. To reach these targets, WWF and a broad coalition of stakeholders are urging the richest and most developed countries to cut their emissions to 40% below 1990 levels by 2020 and developing countries to reduce their emissions by 30% from business-as-usual levels by 2020. These goals are achievable with strong political leadership, participation by all countries, and the sense of urgency this report conveys.

REFERENCES

ADB. 2008. GMS: Climate Makers or Climate Takers? Understanding and Responding to the Challenges of Climate Change. Background Paper. GMS Development Dialogue. 21 May.

ADB. 2009. The Economics of Climate Change in Southeast Asia: A Regional Review. Manila.

Aerts, J., H. Renssen, P. J. Ward, H. de Moel, E. Odada, L. M. Bouwer, and H. Goosse. 2006. Sensitivity of global river discharges under Holocene and future climate conditions. Geophysical Research Letters 33.

Allison, E.H., A.L. Perry, M-C. Badjeck, W.N. Adger, K. Brown, D. Conway, A.S. Halls, G.M. Pilling, J.D. Reynolds, N.L. Andrew and N.K. Dulvy. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries. Blackwell Publishing Ltd. DOI: 10.1111/j. 1467-2979.2008.00310.x.

Baltzer, M.C., T.D. Nguyen, and R.G. Shore (eds). 2001. Towarads a vision for biodiversity conservation in the forests of the Lower Mekong Ecoregion Complex. WWF Indochina/WWF US, Hanoi and Washington, DC.

Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds. 2008. Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp.

Bradshaw, W.E. and C.M. Holzapfel. 2006. Evolutionary response to rapid climate change. Science 312: 1477 - 1478

Campbell, K.M., J. Gulledge, J.R. McNeill, J. Podesta, P. Ogden, l. Fuerth, R. J. Woolsey, A.T.J. lennon, J. Smith, R. Weitz, and D. Mix. 2007. The Age of Consequences. Center for Strategic International Studies and Center for a New American Security.

Carew-Reid, Jeremy, 2007, Rapid Assessment of the Extent and Impact of Sea Level Rise in Viet Nam, Climate Change Discussion Paper 1, ICEM – International Centre for Environmental Management, Brisbane, Australia

Chaudhry P. and Greet Ruysschaert. 2007. Climate Change and Human Development in Vietnam. Human Development Report 2007/2008: Fighting climate change: Human solidarity in a divided world. 2007/46.

Chinvanno, S., S. Souvannalath, B. Lersupavithnapa, V. Kerdsuk, T. Nguyen. 2008. Strategies for managing climate risks in the Lower Mekong River Basin: a place-based approach. Pages 228-246 in N. Leary, J. Adejuwon, V. Barros, I. Burton, J. Kulkarni, and R. Lasco (Eds.) Climate Change and Adaptation. Earthscan, London.

Cornford, J. and Matthews, N. 2007. Hidden Costs: The underside of economic transformation in the Greater Mekong Subregion. Australia: Oxfam Australia.

Dasgupta, S., B. Laplante, C. Meisner, D. Wheeler, and J. Yan. 2007. The impact of sea level rise on developing countries: a comparative analysis. World Bank Policy Research Working Paper 4136.

De Silva, S., and D. Soto. 2009. Climate Change and Aquaculture: Potential Impacts, Adaptation and Mitigation. Technical Paper 530, Food and Agriculture Organization, Rome.

Eastham, J., F. Mpelasoka, M. Mainuddin, C. Ticehurst, P. Dyce, G. Hodgson, R. Ali and M. Kirby. 2008. Mekong River Basin Water Resources Assessment: Impacts of Climate Change. CSIRO: Water for a Healthy Country National Research Flagship.

Griffiths, G. M., L. E. Chambers, M. R. Haylock, M. J. Manton, N. Nicholls, H. J. Baek, Y. Choi, P. M. Della-Marta, A. Gosai, N. Iga, R. Lata, V. Laurent, L. Maitrepierre, H. Nakamigawa, N. Ouprasitwong, D. Solofa, L. Tahani, D. T. Thuy, L. Tibig, B. Trewin, K. Vediapan, and P. Zhai. 2005. Change in mean temperature as a predictor of extreme temperature change in the Asia-Pacific region. International Journal of Climatology 25:1301-1330.

Hoanh, C.T., H. Guttman, P. Droogers and J. Aerts. 2004. Will we produce sufficient food under climate change? Mekong Basin (South-east Asia). Climate Change in Contrasting River Basins: Adaptation Strategies for Water, Food, and Environment, Aerts, J.C. J.H. Aerts and P. Droogers, Eds., CABI Publishing, Wallingford, 157–180.

IPCC. 2007. Climate Change 2007. Impacts, Adaptation and Vulnerability. M.L. Parry, O.F. Canziani, J. P. Palutikof, P.J. van der Linden and C.E. Hanson, eds. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

ISET-International and ISET-Nepal. 2008. Climate Adaptation in Asia: Knowledge Gaps and Research Issues in China. The Full Report of the China Team. Joint DFID-IDRC regional consultation to assess regional priorities, capabilities and research gaps on climate change and poverty reduction in Asia. Format Printing Press, Kathmandu, Nepal.

IUCN, IWMI, RAMSAR and WRI. 2003. Watersheds of the World: Global Maps; Freshwater Fish Species Richness by Basin.

Jacobs, J. W. 1996. Adjusting to climate change in the Lower Mekong. Global Environmental Change-Human and Policy Dimensions 6:7-22.

Keskinen, M. 2008. Water resources development and impact assessment in the Mekong Basin: Which way to go? Ambio 37:193-198.

Kummu, M., D. Penny, J. Sarkkula and J. Koponen. 2008 Sediment: curse or blessing for Tonle Sap Lake? Ambio 37: 158-163.

Lamberts, D. and J. Koponen. 2008. Flood pulse alterations and productivity of the Tonle Sap Ecosystem: a model for impact assessment. Ambio 37: 178-184.

Malcolm, J.R. C. Liu, R.P. Neilson, L. Hansen, and L. Hannah 2006. Global warming and extinctions of endemic species from biodiversity hotspots. Conservation Biology 20: 538-548.

Manton, M. J., P. M. Della-Marta, M. R. Haylock, K. J. Hennessy, N. Nicholls, L. E. Chambers, D. A. Collins, G. Daw, A. Finet, D. Gunawan, K. Inape, H. Isobe, T. S. Kestin, P. Lefale, C. H. Leyu, T. Lwin, L. Maitrepierre, N. Ouprasitwong, C. M. Page, J. Pahalad, N. Plummer, M. J. Salinger, R. Suppiah, V. L. Tran, B. Trewin, I. Tibig, and D. Yee. 2001. Trends in extreme daily rainfall and temperature in Southeast Asia and the South Pacific: 1961-1998. International Journal of Climatology **21**:269-284.

Niemnil, S., Naeiji, M., Trisirisatayawong, I. 2008. Sea level trend in Gulf of Thailand using satellite altimetry data. Proceedings. Conference on Climate Change impacts on oceans.

Ohlemuller, R., B.J. Anderson, M.B. Araujo, S.H.M. Butchart, O. Kudrna, R.S. Ridgely, and C.D. Thomas. 2008. The coincidence of climatic and species rarity: high risk to small-range species from climate change. Biology Letters, published online doi: 10.1098.

Oxfam International. 2008. Vietnam: Climate Change, Adaptation and Poor People. Oxfam Publishing. www.oxfam.org.uk/pulications.

Penny, D. 2008. The Mekong at climatic crossroads: Lessons from the geological past. Ambio 37:164-169.

Reuters. 2009. Mekong Delta may be inundated by rising sea-study. 20 August.

Rundell, P.W. 1999. Forest habitats and flora in Lao PDR, Cambodia, and Vietnam. WWF Indonchina Desk Study, Hanoi.

Ryvitski, J.P.M, A.J. Kettner, I. Overeem, E.W.H. Hutton, M.T.Hannon, G.R. Brakenridge, J. Day, C. Vörösmarty, Y. Saito, L. Giosan, and R.J. Nicholls. 2009. Sinking deltas due to human activities. Nature Geosciences. Published online: 20 September 2009, doi: 10.1038/ngeo629.

Sivakumar, M. V. K., H. P. Das, and O. Brunini. 2005. Impacts of present and future climate variability and change on agriculture and forestry in the arid and semi-arid tropics. Climatic Change 70: 31–72

Stern, N. 2007. The Economics of Climate Change: The Stern Review. Cambridge: Cambridge University Press.

Stork, N.E., J. Balston, G.D. Farquhar, P.J. Franks, J.A.M. Holtum, and M.J. Liddell. 2007. Tropical rainforest canopies and climate change Austral Ecology 32: 105–112.

TKK & SEA START RC. 2009. Water and Climate Change in the Lower Mekong Basin: Diagnosis and recommendations for adaptation. Water and Development Research Group, Helsinki University of Technology (TKK), and Southeast Asia START Regional Center (SEA START RC), Chulalongkorn University. Water & Development Publications, Helsinki University of Technology, Espoo, Finland.

Trisurat, Y., Alkemade, R., and Arets, E. 2009. Projecting forest tree distributions and adaptation to climate change in northern Thailand. Journal of Ecology and Natural Environment. Vol 1 (3). Pp. 055-063.

UNEP. 2009. Ecofacts: Climate Change in Bangkok.

Warner, K., Ehrhart, C., de Sherbinin, A., Adamo, S.B., Onn, T.C. (2009) "In search of Shelter: Mapping the effects of climate change on human migration and displacement." A policy paper prepared for the 2009 Climate Negotiations. Bonn, Germany: United Nations University, CARE, and CIESIN-Columbia University and in close collaboration with the European Commission "Environmental Change and Forced Migration Scenarios Project", the UNHCR, and the World Bank.

Wassmann, R., N. X. Hien, C. T. Hoanh, and T. P. Tuong. 2004. "Sea Level Rise Affecting the Vietnamese Mekong Delta: Water Elevation in the Flood Season and Implications for Rice Production." Climatic Change 66:89–107.

Wilkes, A. 2008. Towards Mainstreaming Climate Change in Grassland Management Policies and Practices on the Tibetan Plateau. WP number 67. Beijing, China. World Agroforestry Centre-ICRAF China. 43pp.

Williams, J.W., S.T. Jackson, and J.E. Kutzbach, 2007: Projected distributions of novel and disappearing climates by 2100 AD. Proceedings of the National Academy of Sciences of the United States of America **104**: 5738-5742.

World Bank. 2009. World Development Report 2010: Development in a Changing Climate. Washington, D.C.

WorldFish Center. 2008. Don't let fish slip through the climate change net. http://www.worldfishcenter.org.

World Water Assessment Programme 2009. The United Nations World Water Development Report 3: Water in a Changing World. Paris: UNESCO, and London: Earthscan.

WWF. 2008a. Prospects and drivers for agricultural change in the Mekong region: The case of sugar, rice and rubber. Vientiane, Lao PDR.

WWF. 2008b. Cracking the Climate Nut at COP 14: WWF Position Paper for the UNFCCC Climate Change Conference in Poznan, Poland. December.

WWF. 2009. First Contact in the Greater Mekong: New Species Discoveries. Hanoi, Vietnam.

WWF and SEA START RC. 2008. Climate change impacts in Krabi province: A study of environmental, social, and economic challenges. Bangkok, Thailand.

WWF Australia and the University of Queensland. 2009. The Coral Triangle and Climate Change: Ecosystems, People and Societies at Risk.

Xu, J. 2008. The highlands: a shared water tower in a changing climate and changing Asia. WP number 64. Beijing, China, World Agroforestry Centre – ICRAF China. 53p.

Yusuf, A.A. and Francisco, H.A. 2009. Climate Change Vulnerability Mapping for Southeast Asia. Economy and Environment Program for Southeast Asia (EEPSEA). Singapore.

WWF is working to conserve 600,000km2 of the world's most:
- biologically diverse,
- economically viable and
- seriously threatened

forests and rivers within the Greater Mekong, home and life source to over 300 million people in Cambodia, China, Lao PDR, Myanmar, Thailand, and Vietnam.

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