In Search of Shelter

Mapping the Effects of Climate Change on Human Migration and Displacement

Koko Warner, Charles Ehrhart, Alex de Sherbinin, Susana Adamo, and Tricia Chai-Onn

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Women and children displaced by floods, which had immeadiately followed a drought, in Northeastern Kenya

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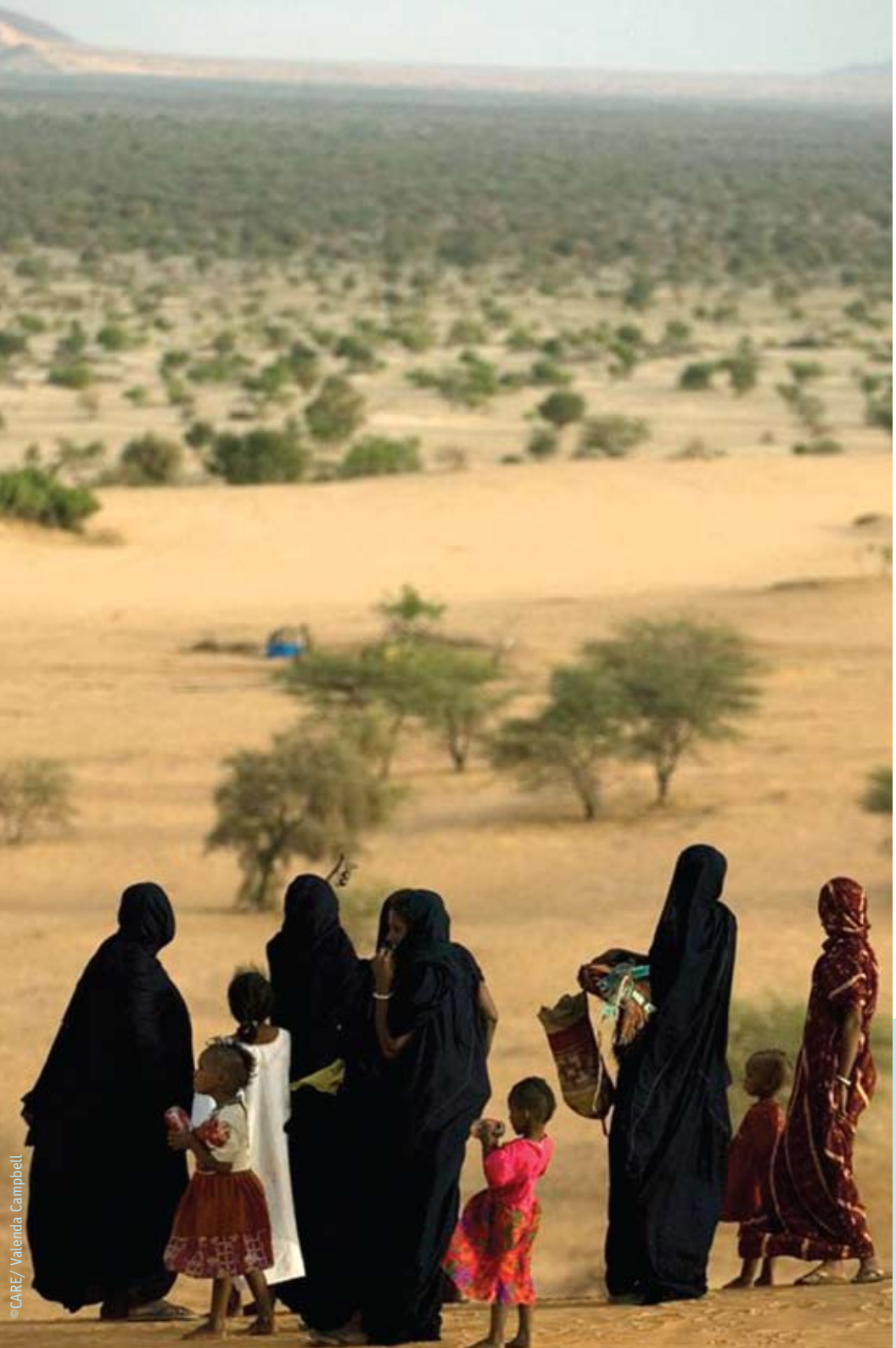

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Executive Summary

The impacts of climate change are already causing migration and displacement. 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 in the least developed countries and island states will be affected first and worst.

The consequences for almost all aspects of development and human security could be devastating. There may also be substantial implications for political stability.

Most people will seek shelter in their own countries while others cross borders in search of better odds. Some displacement and migration may be prevented through the implementation of adaptation measures. However, poorer countries are under-equipped to support widespread adaptation. As a result, societies affected by climate change may find themselves locked into a downward spiral of ecological degradation, towards the bottom of which social safety nets collapse while tensions and violence rise. In this all-too-plausible worst-case scenario, large populations would be forced to migrate as a matter of immediate survival.

Climate-related migration and displacement can be successfully addressed only if they are seen as global processes rather than local crises. The principle of common but differentiated responsibilities—both in terms of minimizing displacement and supporting unavoidable migration—must, therefore, underlie policy negotiations and subsequent outcomes. The burden of assisting and protecting displaced populations cannot be allowed to fall on the shoulders of most affected states alone.

Nature and purpose of this report

This report explores how environmental shocks and stresses, especially those related to climate change, can push people to leave their homes in search of "greener pastures" … or just to survive. In order to make informed decisions, policymakers and development actors need a better understanding of the linkages between environmental change, displacement and migration. This report, therefore, offers:

- empirical evidence from a first-time, multi-continent survey of environmental change and migration based in part on empirical evidence from a recently completed research project supported by the European Commission: Environmental Change and Forced Migration Scenarios (EACH-FOR, Contract Number 044468, www.each-for.eu)
- original maps illustrating how, and where, the impacts of climate change may prompt significant displacement and migration;
- policy recommendations that reflect the collective thinking of key multi-lateral and research institutions, as well as non-governmental organizations working directly with many of the world's most vulnerable populations.

> Policy decisions made today will determine whether migration becomes a matter of choice amongst a range of adaptation options, or merely a matter of survival due to a collective failure by the international community to provide better alternatives.

Key findings

- Climate change is already contributing to displacement and migration. Although economic and political factors are the dominant drivers of displacement and migration today, climate change is already having a detectable effect.
- The breakdown of ecosystem-dependent livelihoods is likely to remain the premier driver of long-term migration during the next two to three decades. Climate change will exacerbate this situation unless vulnerable populations, especially the poorest, are assisted in building climate-resilient livelihoods.
- Disasters continue to be a major driver of shorter-term displacement and migration. As climate change increases the frequency and intensity of natural hazards such as cyclones, floods, and droughts, the number of temporarily displaced people will rise. This will be especially true in countries that fail to invest now in disaster risk reduction and where the official response to disasters is limited.
- Seasonal migration already plays an important part in many families' struggle to deal with environmental change. This is likely to become even more common, as is the practice of migrating from place to place in search of ecosystems that can still support rural livelihoods.
- Glacier melt will affect major agricultural systems in Asia. As the storage capacity of glaciers declines, short-term flood risks increase. This will be followed by decreasing water flows in the medium- and long-term. Both consequences of glacier melt would threaten food production in some of the world's most densely populated regions.
- Sea level rise will worsen saline intrusions, inundation, storm surges, erosion, and other coastal hazards. The threat is particularly grave vis-à-vis island communities. There is strong evidence that the impacts of climate change will devastate subsistence and commercial agriculture on many small islands.
- In the densely populated Ganges, Mekong, and Nile River deltas, a sea level rise of 1 meter could affect 23.5 million people and reduce the land currently under intensive agriculture by at least 1.5 million hectares. A sea level rise of 2 meters would impact an additional 10.8 million people and render at least 969 thousand more hectares of agricultural land unproductive.
- Many people won't be able to flee far enough to adequately avoid the negative impacts of climate change—unless they receive support. Migration requires resources (including financial, social, and political capital) that the most vulnerable populations frequently don't have. Case studies indicate that poorer environmental migrants can find their destinations as precarious as the places they left behind.

Policy Recommendations

New thinking and practical approaches are needed to address the threats that climate-related migration poses to human security. These include the following principles and commitments for action by stakeholders at all levels:

Avoid dangerous climate change

Reduce greenhouse gas emissions to safe levels.

The international community has until December 2009, at the Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC), to agree on a way forward. If this deadline isn't met, we will almost surely shoot past any safe emissions scenario and commit future generations to a much more dangerous world in which climate change-related migration and displacement, on a truly massive scale, is unavoidable.

Focus on human security

Protect the dignity and basic rights of persons displaced by climate change.

Climate-related displacement and migration should be treated, first and foremost, as a "human security" issue. Sensationalist warnings must not be permitted to trigger reactionary policies aimed at blocking the movement of "environmental refugees" without genuine concern for their welfare.

Invest in resilience

Increase people's resilience to the impacts of climate change so that fewer are forced to migrate.

The breakdown of natural-resource dependent livelihoods is likely to remain the premier driver of long-term migration during the next two to three decades. Climate change will exacerbate the situation unless vulnerable populations, especially the poorest, are assisted in building climate-resilient livelihoods. This will require substantial investment in:

- in situ adaptation measures including, for instance, water-wise irrigation systems, low/no-till agricultural practices, income diversification, and disaster risk management;
- the empowerment of women and other marginalized social groups to overcome the additional barriers they face to adaptation; and
- inclusive, transparent, and accountable adaptation planning with the effective participation of especially vulnerable populations.

Prioritize the world's most vulnerable populations

Establish mechanisms and binding commitments to ensure that adaptation funding reaches the people that need it most.

Negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) are currently focused on how to generate sufficient funds for adaptation in developing countries and how the funds should be managed. These are important questions. However, it is equally important to determine how funds will be channeled so that they reach the people who need them most. Objective criteria for assessing vulnerability to the negative impacts of climate change—including people's risk of displacement—should be developed to guide priority assistance.

Include migration in adaptation strategies

Recognize and facilitate the role that migration will inevitably play in individual, household and national adaptation strategies.

For millennia, people have engaged in long- and short-term migration as an adaptive response to climatic stress. Millions of individuals and households are employing a variant of this strategy today. Human mobility—permanent and temporary, internal and cross border—must be incorporated into rather than excluded from international and national adaptation plans. This can be done in a variety of ways at a number of levels and may include:

- measures to facilitate and strengthen the benefits of migrant remittances;
- the rights-based resettlement of populations living in low-lying coastal areas and small island states.[1]

Environmentally, socially and economically sustainable resettlement meeting human rights standards (as reflected inter alia in the Guiding Principles on Internal Displacement) can be costly; and international agreements must address how these and related needs will be met. Existing mechanisms for adaptation funding, which rely on voluntary contributions, have failed to deliver. Therefore, future agreements under the UN Framework Convention on Climate Change must establish binding commitments for historic high emitters. These funds must be new and additional to existing commitments, such as those for Official Development Assistance.

Close the gaps in protection

Integrate climate change into existing international and national frameworks for dealing with displacement and migration.

The unique challenges posed by climate change must be factored into norms and legal instruments dealing with displacement and migration. Especially important conundrums surround:

- disappearing states and non-viable homelands. Unlike some people displaced by conflict or persecution who may one day return home, those displaced by the chronic impacts of climate change (e.g. inadequate rainfall and sea level rise) will require permanent resettlement.
- irrevocably deteriorating living conditions. Climate change will result in cases that do not fit into current distinctions between voluntary and forced migration. At present, people who move due to gradually worsening living conditions may be categorized as voluntary economic migrants and denied recognition of their special protection needs.

In order to satisfactorily address such challenges, duty-bearers will need clear guidelines for protecting the rights of environmentally-induced migrants.

Strengthen the capacity of national and international institutions to protect the rights of persons displaced by climate change.

Institutions tasked with protecting the basic rights of migrants and displaced persons are already under-funded and overstretched. Climate change will add to their strain, making the practice of protection even more difficult. The international community must, therefore, begin substantial discussions about how to realize its duties to protect migrants and displaced persons under conditions of radical environmental change.

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1. Introduction

Until recently, climate change research and negotiations have focused almost exclusively on the imperative of reducing greenhouse gas emissions. Now, however, it is clear that emissions reductions efforts have been too little, too late.[2] Therefore, the challenges and complex politics of adaptation are joining those of mitigation at the centre of policy debates.

It is, therefore, crucial for the international community to accelerate learning about effective adaptation. One of the most important tasks will be to improve our understanding of how environmental change affects human mobility. In any given location, migration could be an adaptation strategy. But forced migration and displacement may well be indicators of woefully inadequate adaptive capacity.

Migration and global environmental change

Our world has experienced profound climatic changes before. What appears to be different this time is that one species, humans, is contributing to the change, and that climate change is impacting the ecosystems on which it depends.

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.

Migration—whether permanent or temporary, internal or international—has always been a possible adaptation strategy for people facing environmental changes. Pre-history and history are marked by migration and displacement from one climate zone to another, as people sought out environments that would support survival as well as aspirations for a better life. Some waves of migration and displacement have been associated with cultural collapse, as familiar landscapes no longer provided safe or supporting habitats and livelihoods for people.

Today, environmental change, including climate change, presents a new threat to human security and a new situation for human mobility. By 2050 when human population is projected to peak, some 9 billion people will live on Earth. The majority of them will live in urban areas with crushing environmental footprints. Many megacities are located in areas prone to sea level rise. Climate change will visit urban and rural areas alike with increasingly frequent and violent hazard events. Flooding, intense storms, or droughts, or more gradual but significant changes in regional climates place great stress on livelihood systems. These pressures will contribute to migration and displacement, along with myriad other factors.

In coming decades, climate change will motivate or force millions of people to leave their homes in search of viable livelihoods and safety. Although the precise number of migrants and displaced people may elude science for some time, the mass of people on the move will likely be staggering and surpass any historical antecedent.

Most people will seek shelter in their own countries while others will cross borders in search of better chances. Some migration and displacement will be prevented through adaptation measures, including changes in agricultural productivity and integrated water management. However, poorer countries are under-equipped to implement wide-spread adaptation activities; and migration will be the only option for many people in the South. Our responses to climate change today will help determine whether migration will be a matter of choice in a wider range of adaptation options, or whether forced migration and displacement will be a matter of mere survival due to a collective failure to provide adequate adaptation alternatives.

New thinking and the contribution of this report

New thinking and practical approaches are needed to address the threats that environmental change including climate change poses for migration and displacement. Migration is a significant—and growing response to climate change, yet neither the literature on climate change nor on human mobility yet fully reflects this adaptation option, its impacts, or policy alternatives. Policy-makers require better information, empirical data, and analysis of both the threats and potential solutions. This report seeks to respond to that need, and helps to fill the gaps by providing:

- empirical evidence from a first-time multi-continent survey of environmental change and human mobility;[3]
- original maps of climate change impacts and population distributions, representing some of the major processes associated with climate change, and some of the major human-ecological systems where these changes could prompt migration and displacement. Presenting recent country case studies, the paper looks at current patterns of climate change and migration for glacier melt and the major river systems in Asia, drying trends in Central America and Western Africa, flooding and sea level rise in major deltas of the world, and sea level rise in low-lying Small Island developing states (for details, see Technical Annex: Data and Methods);
- policy recommendations that reflect the collective thinking of key multi-lateral and research institutions, as well as non-governmental organizations working directly with many of the world's most vulnerable populations.

What this report does not do

This report does not attempt to provide estimates of the numbers of people that may move or be forced to move in response to environmental factors including climate change. The report does not attempt to indicate specific geographical destinations for migrants in the future. The report does not attempt to draw causal relationships between climate change and migration or displacement, but rather relies on current scientific understanding of environmental processes and how these processes can affect human mobility. The authors hope that this report will be useful in discussions of where migration and displacement pressures are currently and where they may emerge in the future, related to phenomena such as glacial melting, drying trends, extreme events like flooding, and sea level rise. The report is intended to present plausible future developments that provide decision makers a basis for focusing their discussions on the role of human mobility in adaptation.

2. Adaptation, or failure to adapt?

Multiple drivers

Today, environmental change including climate change contributes to human mobility embedded in linked environmental and social processes.[4] Social system characteristics including social networks play a mediating role in how environmental change affects whether people move away or stay at home.[5] Migration can represent a response to changing environmental and economic conditions, such as a farmer´s choice to migrate due to failing crops and insecure livelihood prospects. Migration can also exacerbate environmental and economic problems in receiving areas. For example, urban areas attract migrants seeking better lives. High in-migration contributes to crowding and environmental/ sanitation issues in slums.

Studies also point towards urbanization as a force driving regional warming (heat islands) which can exacerbate drying trends, among other problems.[6] Some of these cities, such as Dhaka, Buenos Aires, Rio de Janeiro, Shanghai and Tianjin, Alexandria and Cairo, Mumbai and Kolkata, Jakarta, Tokyo and Osaka-Kobe, Lagos, Bangkok, New York City, and Los Angeles, are located in areas exposed to sea level rise. Sea level rise could motivate resettlement, forced migration, or other forms of human mobility.[7]

Environmental change has a multiplier effect on other migration drivers.[8] As an illustration, land degradation in Niger has undermined the resilience of farmers to recurring drought.[9] More erratic weather, rising sea level and other climate change impacts will exacerbate both migration pressures and environmental degradation.[10]

What is certain from empirical and theoretical research on environmentally-induced migration, in all its varieties, is that environmental change is one of many contributing factors.

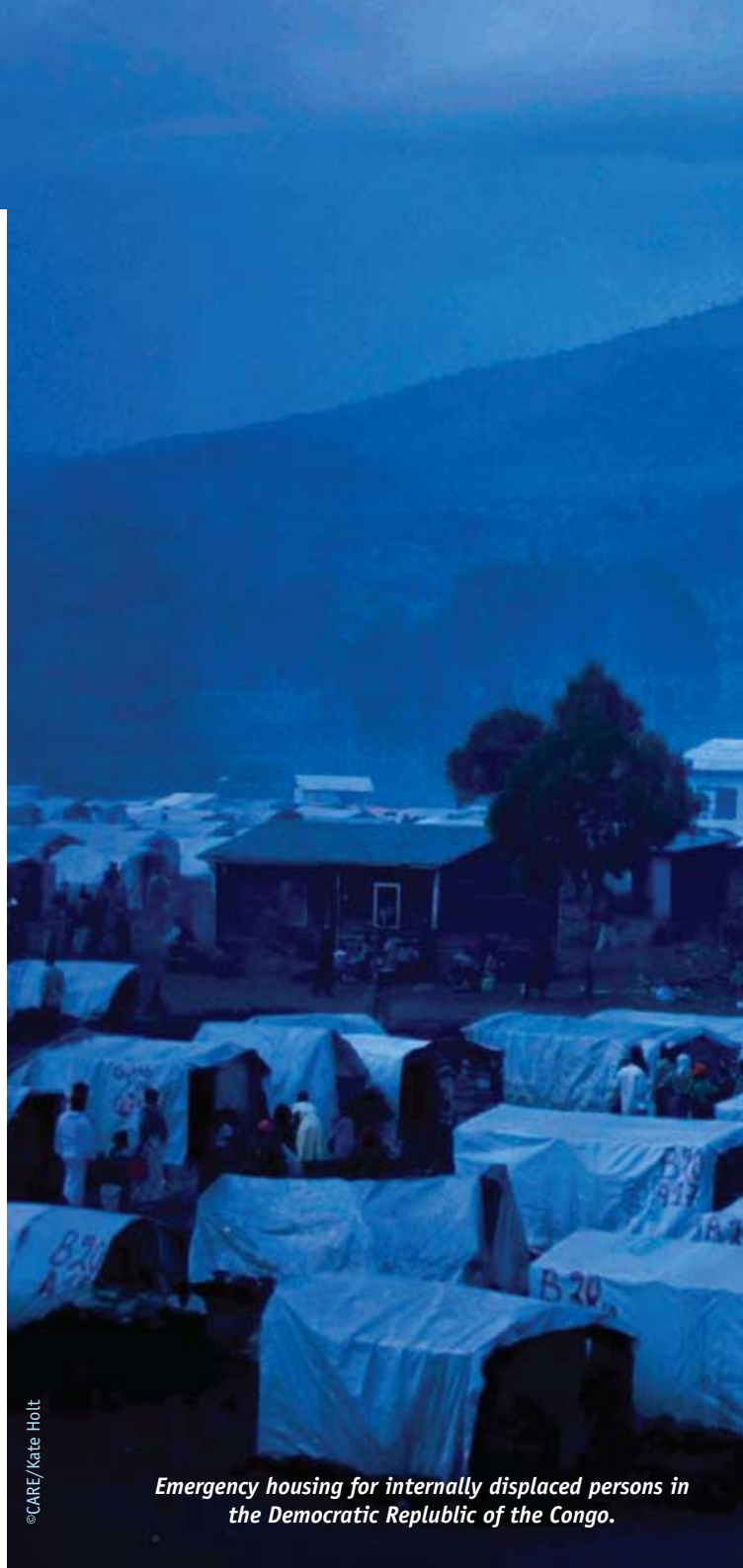
Climate change & mobility: framing the issue

Terms and concepts such as environmental or climate change migration, environmentally-induced or forced migration, ecological or environmental refugees, and climate change refugees are used throughout the emerging literature, with no general agreement on precise definition.[16] The main reason for the lack of definitions for migration caused in part by environmental change and degradation is linked to two issues: the challenge of isolating environmental factors from other migration drivers, and the possible institutional and governance implications of defining this range of environmentally-related migration.[17]

This report relies on a working definition provided by the International Organization for Migration (IOM) for "environmentally-induced migrants" including those made mobile in part due to climate change: "Environmental migrants are persons or groups of persons who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad."[18]

How many people will be uprooted by environmental change?

Estimates of the numbers of migrants and projections of future numbers are divergent and controversial.[11] [12] IOM takes the middle road with an estimate of 200 million environmentally-induced migrants by 2050.[13] The first controversy concerns the categorization of people made mobile by environmental factors including climate change. Some organisations refer to "environmental refugees" while others, following the strong position of UNHCR, stress that the word "refugee" has a specific legal meaning in the context of the 1951 Geneva Convention Relating to the Status of Refugees.[14] Terms such as "environmental migrants" and "environmentally motivated migrants" have, therefore, been introduced as alternatives.[15]



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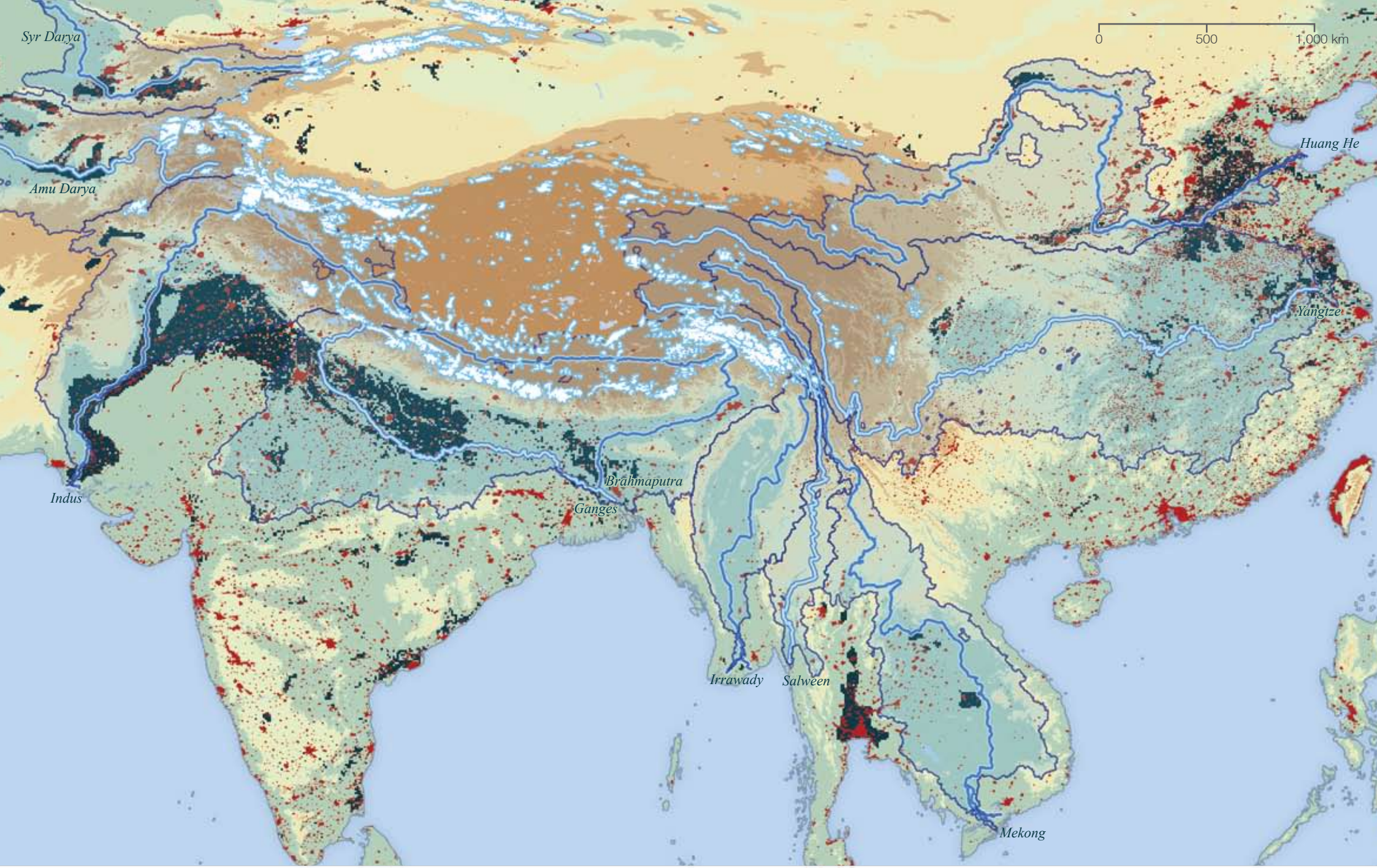
Emergency housing for internally displaced persons in the Democratic Replublic of the Congo.

3. Climate change and human mobility

This section explores the regional dynamics of climate change processes and human mobility, looking at glacial melt, drying trends, flooding and sea level rise in some of the world's hotspot areas. The key contribution of this report is the combination of unique maps of climate change-related trends and population distribution patterns, and fieldwork exploring the impacts of environmental change on migration, particularly the EACH-FOR project.

The point of departure for this paper is the underlying hypothesis that environmental change affects human mobility most directly through livelihoods which are dependent on ecosystem services, such as agriculture, herding and fishing. This hypothesis was formed after a series of field investigations where researchers assessed the nature of the linkages between environmental stressors and migration. In the EACH-FOR project, the majority of migrants interviewed indicated that if the environment had affected a decision to migrate, it was most often because environmental changes had made it difficult for the individual or family to earn a living. These observations led to the formation of the hypothesis above.

In this section, the reader follows a journey from the water towers of Asia—the Himalayan glaciers—to the drylands of Central America and Western Africa (the Sahel), then on to three of the world's major deltas (the Ganges, the Mekong, and the Nile). The journey ends with some of the low lying island states of Tuvalu and Maldives. Each area highlighted in this section has one map accompanied by a box explaining some of the key messages of each map, followed by findings from the field about the relationship between climate change, migration, and displacement.


Syr Darya
Amu Darya
Indus
Brahmaputra
Ganges
Irrawady
Salween
Mekong
Huang He
Yangtze
0
500
1,000 km
Glaciers
Rivers
Basins
Irrigated Areas
Urban Extent
Elevation (meters)
0 – 500
500 – 1,000
1,000 – 2,000
2,000 – 4,000
4,000 – 6,000
6,000 – 8,000

3.1 Asia: Glacier melt and irrigated agricultural systems

Globally, glaciers are retreating at alarming rates.[19] Glaciers are slow moving masses of ice that store accumulated snowfall over decades and even centuries. Glaciers flow down mountainsides, melting at the lower ends while more snow accumulates at the upper ends. Because of this constant regeneration through winter snow pack, they store water during winter months and feed rivers during summer months, regulating the flow downstream.[20]

Shrinking glaciers provide a one-time "dividend" of water release to downstream regions.[21] As the storage capacity of glaciers is lost, flooding risks increase in the medium term. This can affect rural agriculture and urban areas located in river deltas. Once the glacier disappears, it no longer releases water during the summer months. The disappearance of glaciers implies decreased water supply and untimely flows—that is, coming in the wrong (non-cropping) season. The only alternative for seasonal water storage are dams, which are costly to construct and can have significant environmental and social impacts, resulting in the displacement of thousands or, in rare cases, millions of people.[22]

The Himalayas are known as the Water Tower of Asia. The glacier-fed rivers originating from the Himalaya mountain ranges surrounding the Tibetan Plateau comprise the largest river run-off from any single location in the world.[23] The rivers that drain these mountains move through some of the most populous areas in the world. In the year 2000, the river basins of the Indus, Ganges, Brahmaputra, Irrawaddy, Salween, Mekong, Yangtze, and Huang He (Yellow) Rivers collectively supported a population of 1.4 billion people, or almost a quarter of the world's population.

Himalayan glaciers are already in retreat.[24] Their dependence on glacier runoff makes downstream populations particularly vulnerable to the consequences. The Indus River valley supports one of the largest irrigation works in the world (16.2m ha). Approximately 90 percent of Pakistan's crop production is grown under irrigation, and all of the water comes from barrages along the Indus. The Ganges, Yangtze, and Yellow Rivers also have large areas under irrigation —17.9m ha, 5.4m ha, and 2.0m ha, respectively.

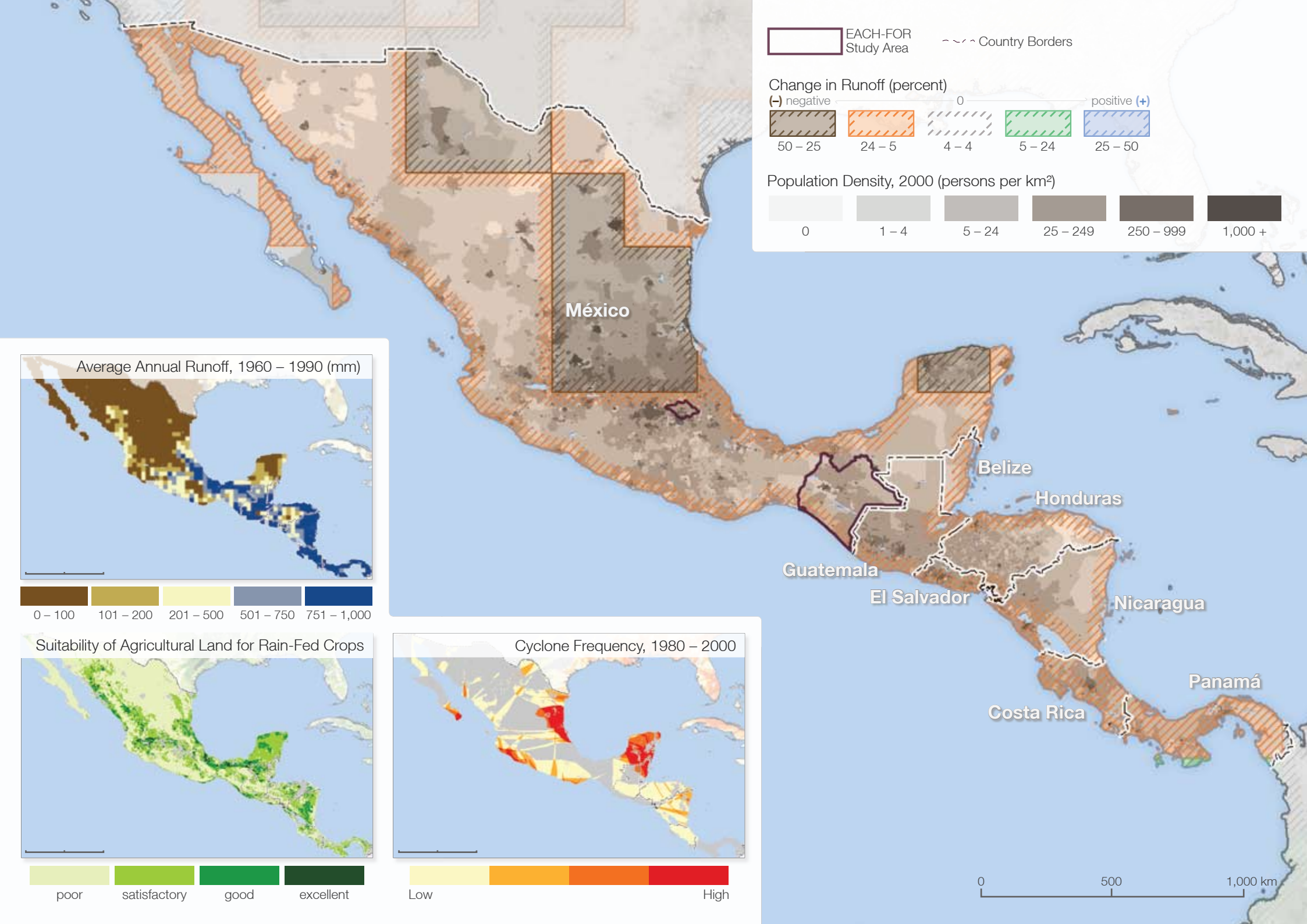
Hydropower installations along the Mekong and Yangtze are also significant suppliers of electricity to urban markets. The recently completed Three Gorges Dam on the Yangtze, the world's largest hydroelectric installation, will have a power generation capacity of 22,500 MW once all generators are installed, more than 20 times the capacity of an average coal-fired or nuclear power plant. The project, however, has already displaced 1–2 million people.[25] Plans are underway to add significant hydropower generating capacity to the Mekong over the coming decades. Under scenarios of rapid glacier melt, it is likely that hundreds more water retention dams will be constructed. Collectively, these will have significant impacts on downstream flow regimes and deltas, which are already starved of flood waters and replenishing sediment.[26] Population displacement and resettlement will become larger issues in these areas at significant scales.

As a result of the intensification of cultivation in irrigated areas and power generation, many millions indirectly depend on the food and energy resources generated by these great rivers. But the rivers also provide direct livelihoods to all those employed in irrigated agriculture, small-scale fishing, and aquaculture, and they are at the heart of cultural traditions. For example, to Hindus the Ganges is sacred, and is personified in Mother Gaṅgā (Gaṅgā Mātā), representative of life-giving maternal waters.[27] Changes in the rivers and livelihoods dependent on them could bring profound economic, cultural, and demographic impacts.

Should flow reductions become acute, the potential for migration out of irrigated areas could be significant.[28] Although destination areas are hard to predict, it is likely that most migrating or displaced people would move to small to medium sized cities inland, and a smaller number would move to large megacities along the coasts or on the main branches of river systems (e.g. Delhi).[29] Movement from interior to coastal areas—a pattern that has been prevalent in China since the early 1980s—will result in larger populations vulnerable to sea level rise, and possibly to extreme floods from upstream regions as the regulating effect of glaciers diminish.[30] However, many South Asia cities lack the capacity to absorb significant migration streams. There is potential for significant water saving efficiencies in irrigated areas of Asia, and if properly implemented this may forestall displacements of farmers.[31]

What does this map tell us?

The map depicts glaciers (white with blue border) in the Himalayas and the major rivers that flow from them. These rivers support large irrigated areas (dark green) and major population centers (red), yet the glaciers that feed them are in retreat. Reductions of river flows will affect irrigated areas, but the potential for migration out of agricultural areas is hard to predict, and will depend on adaptation responses such as dam construction and more efficient irrigation technologies. Broader impacts on food security for this highly populous region could be significant. In the absence of diversification and adaptation/mitigation measures, as water resources gradually diminish agriculture livelihoods will become unsustainable, and people may be forced to leave. Paradoxically, measures to store water and ward off a water crisis related to shrinking glaciers could result in further displacement and resettlement.


EACH-FOR Study Area
Country Borders
Change in Runoff (percent)
(–) negative
0
positive (+)
50 – 25
24 – 5
4 – 4
5 – 24
25 – 50
Population Density, 2000 (persons per km²)
0
1 – 4
5 – 24
25 – 249
250 – 999
1,000 +
México
Belize
Honduras
Guatemala
El Salvador
Nicaragua
Panamá
Costa Rica
Average Annual Runoff, 1960 – 1990 (mm)
0 – 100
101 – 200
201 – 500
501 – 750
751 – 1,000
Suitability of Agricultural Land for Rain-Fed Crops
poor
satisfactory
good
excellent
Cyclone Frequency, 1980 – 2000
Low
High
0
500
1,000 km

3.2 Mexico and Central America: Migration in response to drought and disasters

Multiple climate-related hazards threaten Mexico and Central America. This region is known for the severity of cyclone events, with Hurricane Mitch in 1998 leaving devastation in its wake in Honduras and Nicaragua, and Hurricane Stan in 2005 affecting Mexico and Guatemala. Tropical storm Noel in 2007 caused heavy flooding in the state of Tabasco, where up to 80 percent of the state was inundated. Several coastal regions in Mexico will face sea level rise, particularly low lying areas of the Gulf Coast and the Caribbean.[32]

Of particular concern, however, is the likelihood that the region will see persistent declines in precipitation over the course of this century. The map at left shows that runoff in the region will likely decline by at least 5 percent and possibly up to 50 percent, with declines getting progressively worse in the semiarid and arid north.[33] Given the region's mountainous topography, extensive irrigation is only practicable in the coastal plains that are dominated by wealthy landowners. Most smallholder farmers will remain heavily dependent on rain-fed agriculture. However, even large-scale irrigated areas, such as those in Sonora and Sinaloa states, the breadbasket of Mexico, will be affected as average reservoir levels decline. Already, summer droughts during El Niño and La Niña events can lead to serious deficits in reservoir levels.[34] In the case of Guatemala, longer and more intense midsummer drought periods have been linked to long-term declines in rainfall since the 1970s.[35] This drought determines the level of success or failure of rain-fed agriculture.

Processes of slow-onset land degradation including deforestation, soil erosion, and desertification already affect large parts of the Mexico and Central America. In the fragile arid and semi-arid ecosystems of northern and north-western Mexico more than 60 percent of the land is considered to be in a total or accelerated state of erosion, and mountainous lands with high slopes throughout the region have suffered deforestation and soil erosion.

EACH-FOR studies were conducted in the hurricane-prone Chiapas state of Southern Mexico, and in Tlaxcala state, a highly desertified state in Central Mexico. Both areas are considered very vulnerable to the effects of climate change, particularly in combination with deforestation, erosion, and underlying poverty and social vulnerability.[36]

Migration is already a response in Mexico to changing environmental conditions, the 1980s agricultural crisis and economic liberalization.[37] When Hurricane Stan passed through Chiapas, many people were surprised by the violence of its impact. One interviewee noted, "The river took away our homes and properties; we also were close to being taken away."[38] Yet when very low-income villagers were asked whether migration was an option for them, most respondents underlined that they have no other place to go. Yet, for those who are better off or who have relatives abroad, migration is an option.

The recurrence of natural disaster combined with the presence of relatives who emigrated due to disasters in the past increases the desire of farmers to emigrate.[39] On the other hand, diversification of livelihood strategies[40] and government investment on disaster risk management decreases the likelihood of migration, regardless of poverty status.[41]

Some studies have shown links between desertification and migration in Mexico,[42] noting the impacts on agricultural livelihoods. In dryland areas such as Tlaxcala, which depends on rain-fed agriculture, the majority of interviewees complained of shifting rainfall periods, which increases uncertainty and causes a decline in crop yields and incomes. The area of Tlaxcala is projected to have a 10–20 percent decline in runoff in association with climate change. This indirect link between climatic changes and migration was noted frequently in fieldwork, mostly related to unreliable harvests linked to changing rainfall patterns. Return migration, and seasonal migration as a livelihood diversification strategy have been documented in this area. As explained by two interviewees:

> *"…when our harvest is bad, we have to rely on ourselves. Many of us had to leave, to Canada or the United States… the money I made there… was a big help for my family. Without that income, it would have become extremely difficult."*[43]

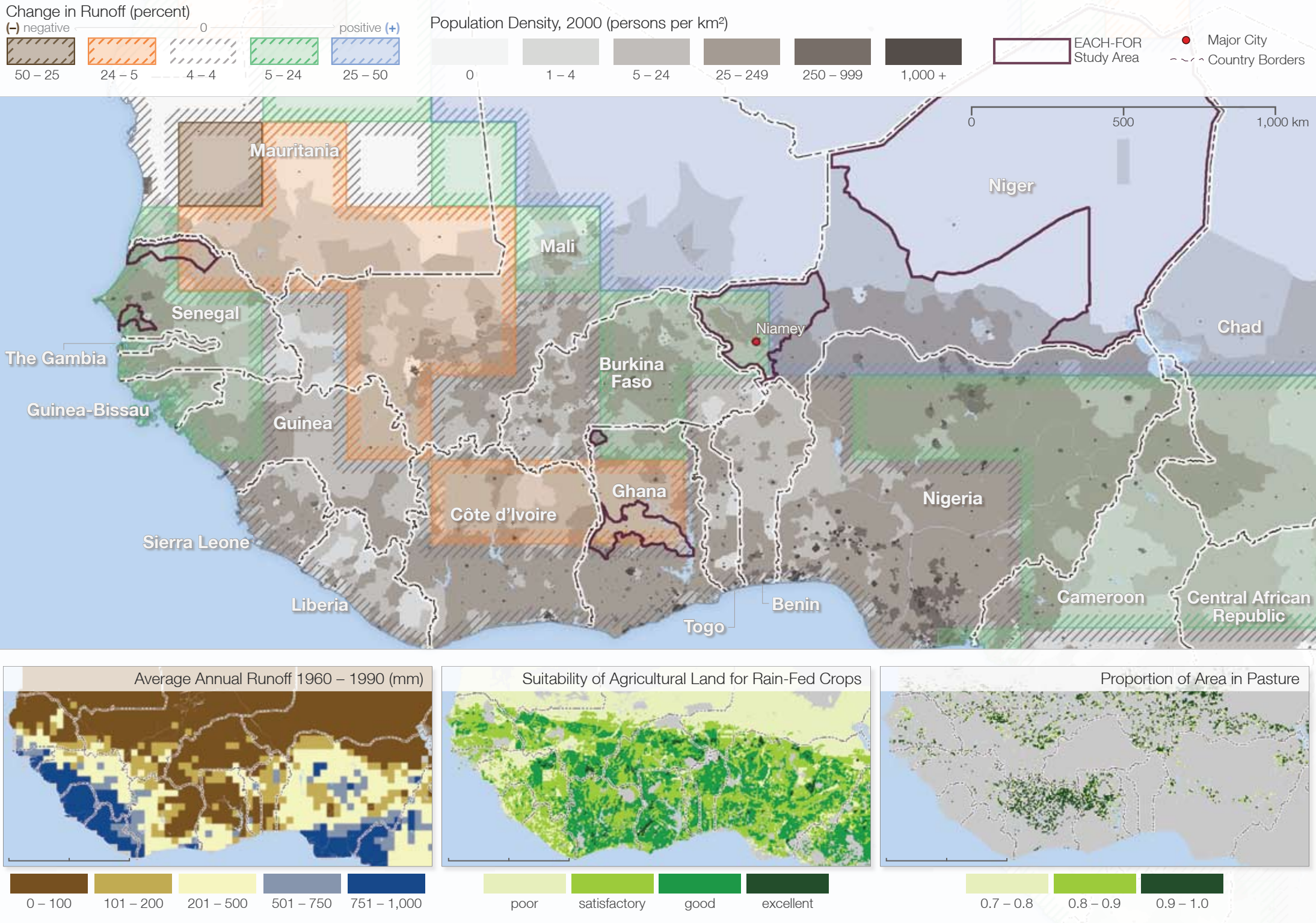
> *"My grandfather, father and I have worked these lands. But times have changed…the rain is coming later now, so that we produce less. The only solution is to go away, at least for a while [to the United States]. But leaving my village forever? No. I was raised here and here I will stay."*[44]

The relevance temporary migration and remittances to cope with unreliable income from agriculture has often been highlighted in the environment-migration literature but not always sufficiently considered in adaptation and mitigation policies.

Internal and international migration patterns are well established in Mexico and Central America,[45] and it is difficult to project what effects drying trends associated with climate change may have. It is clear, however, that environmental factors like desertification and extreme weather already contribute to the regions' complex pattern of human mobility. The opportunity for some people to migrate seasonally, send remittances, and return home is an example of migration as an adaptation strategy to deteriorating environmental conditions.

What does this map tell us?

The main map depicts projected changes in runoff by 2080. Runoff is a measure of water availability and represents the amount of rainfall that runs off the land surface after accounting for evaporation, plant transpiration, and soil moisture replenishment. Mexico and Central America will be widely affected by declines. The map also outlines the Mexican states of Tlaxcala and Chiapas, where EACH-FOR conducted research. The top left inset map shows average annual runoff for the 1960–1990 period, a baseline against which future declines will be applied. The bottom left inset map shows lands suited for rain-fed agriculture, which will be particularly affected by progressive drying in the region. Circular, temporary and seasonal migration has traditionally been a means of coping with climate variability in these areas, and permanent internal and international migration out of areas dependent on rain-fed agriculture is a distinct possibility. The inset on the lower right depicts cyclone frequency in the 1980–2000 period. Some models show the number of category 4 and 5 hurricanes increasing in the Caribbean.


Change in Runoff (percent)
(–) negative
0
positive (+)
50 – 25
24 – 5
4 – 4
5 – 24
25 – 50
Population Density, 2000 (persons per km²)
0
1 – 4
5 – 24
25 – 249
250 – 999
1,000 +
EACH-FOR Study Area
Major City
Country Borders
0
500
1,000 km
Mauritania
Mali
Niger
Senegal
Niamey
Chad
The Gambia
Burkina Faso
Guinea-Bissau
Guinea
Ghana
Côte d'Ivoire
Nigeria
Sierra Leone
Liberia
Benin
Togo
Cameroon
Central African Republic
Average Annual Runoff 1960 – 1990 (mm)
0 – 100
101 – 200
201 – 500
501 – 750
751 – 1,000
Suitability of Agricultural Land for Rain-Fed Crops
poor
satisfactory
good
excellent
Proportion of Area in Pasture
0.7 – 0.8
0.8 – 0.9
0.9 – 1.0

3.3 The Sahel: Pressure on agricultural livelihoods and creeping onward migration

Land degradation, desertification, and deforestation are factors that potentially result in mobility as a household adaptation strategy.[46] Land degradation, as defined by Article 1 of the Convention to Combat Desertification, is defined as a "reduction or loss of biological or economic productivity of ecosystems resulting from climatic variations, land uses and a combination of processes such as: soil erosion, deterioration of soil properties and long-term vegetation loss." Thus, losses of land productivity are inextricably linked to climate change.

Although precise estimates of the land affected by degradation are difficult to obtain, some estimates suggest that more than one-third of drylands are affected by land degradation.[47] Land degradation is a major concern in West Africa, where about 65 percent of the cultivable lands have degraded.[48] From 2000-2005, West and Central Africa lost 1.36m ha of forest cover per year, or a total of 67,800 sq km.[49] More than 300 million people in Africa already live with water scarcity, and areas experiencing water shortages are likely to increase by almost a third by 2050.[50]

West Africa is made up of a diversity of ecosystems, ranging from more tropical humid in the South to arid in the North. While climate change projections of seasonal or annual precipitation are uncertain, the projected increase in intensity of rainfall events, superimposed on the region's already high climate variability, is likely going to lead to increased frequency of droughts and floods. Water shortage and land degradation affect large areas of the Sahel, a region south of the Sahara and north of the humid zone that spans west to east across nine countries from Mauritania and Senegal to Sudan. In the Sahelian zone of Western Africa, two different drought events—a large drought from 1968–74 and a slightly less intense one from 1982–84—were among the worst on record.[51] During the first drought, more than 100,000 people died, most of whom were children.[52] By 1974, more than 750,000 people in Mali, Niger and Mauritania were totally dependent on food aid.[53] These droughts and consequent land degradation are now understood to have been caused in part by a pattern of warming of the tropical oceans which itself may have been driven by anthropogenic climate change.[54] Such environmental pressures could grow in the future with climate change.

Forty-four percent of West Africa's population works in the agricultural sector, most of them at a subsistence level.[55] Despite the high dependence on agriculture in this climatically variable region, the actual areas under irrigation are among the lowest on a per-area basis for any region in the world. For example, in Senegal in 2005, only 67,000 ha was irrigated out of 8.8m ha, or less than 1 percent of the total.[56] Although the Sahel has seen a "greening" since the mid-1980s drought, at 2.6 percent the region still has the second highest population growth rate in the world (after Central Africa).[57] This population growth combined with climatic trends and land degradation could lead to:

- declining per capita production for the agriculture, including animal husbandry
- shortage of fuelwood
- declining rainfall in some regions with consequences for rain-fed and irrigated agriculture
- food shortages and famines in drought years
- movement to urban areas or to more fertile farming areas, such as recently opened areas in the Savannah zone owing to the eradication of river blindness.[58]

Migration, particularly circular mobility, is a traditional coping mechanism in the region, representing a livelihood diversification strategy.[59] But in some areas these traditional patterns have changed in recent decades.[60] Each location has its specific characteristics, but migration and pressures on water and land systems are common denominators. A significant proportion of environmental migrants are displaced due to land degradation and drought in the Sahel, though drought-induced migration is often only temporary. Generally, there is a large migration movement to the coastal and urban agglomerations, and to the coastal states.[61]

One study of the impact of climate change on drylands in West Africa noted that between 1960 and 2000, deteriorating situations due to rainfall decreases, land degradation, and violence in the arid and semi-arid areas of Senegal, Mali, Burkina Faso and Niger resulted in a rapid intra-country migration southward and a swelling of big cities like Dakar, Bamako, Ouagadougou, Niamey and Kano.[62] Estimates for Burkina Faso suggest that close to half of the adult population born there has moved for at least part of the year to coastal states like Ivory Coast and Ghana.[63]

Even those not directly dependent on natural resources for their livelihoods can be affected by desertification and motivated to migrate. One migrant from the Difa region in Niger remarked, "I used to live in the Lake Chad region where my activities were not directly related to the Lake. I used to be a merchant. However, when the lake dried out, people depending on it left for other countries and therefore, my business was negatively affected and I had to leave for Nigeria."[64]

What does this map tell us?

The main map depicts projected declines in runoff by the year 2080 superimposed on population density. Runoff is a measure of water availability, and represents the amount of rainfall that runs off the land surface after accounting for evaporation, plant transpiration and soil moisture replenishment. The maroon outlined areas depict EACH-FOR study areas. The lower left inset map shows average annual runoff for the 1960–1990 period, a baseline against which future declines are compared. The center inset map provides the area suitable for rain-fed agriculture, which largely reflects the population density map. The right inset map shows pasture lands distribution, an important livelihood for many in the Sahel. In this region of scarce water resources and high climate variability, any decline in runoff or change in rainfall patterns will adversely affect the livelihoods of subsistence farmers and pastoralists. Projected drying trends in a context of poverty, inequality, limited diversification options and erratic government support could contribute to transform current patterns into a more permanent, long-term dynamic.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Traditionally pastoralism has represented an important mechanism for adjusting to climate variability, since pastoralists can move their herds along with the rainfall.[65] A symbiotic relationship often formed between herders and agriculturalists, with agriculturalists receiving animal manure to fertilize their crops in return for allowing livestock to graze on plant stubble. However, as the Sahel has become more densely settled, increasingly severe conflicts over land and water resources have erupted between pastoralists and sedentary farmers.[66]

In Senegal, fieldwork revealed that environmental changes negatively affect agricultural livelihoods, and contribute to migration through different mechanisms. For areas where irrigated agriculture is possible, farmers living close to the Senegal River expect their way of life will continue to be possible and therefore do not intend to migrate in the future. But in areas like the Peanut Basin, where land degradation is severe, interviewees said they plan to move away if agricultural livelihoods do not improve. Most migrants who already migrated said they would return home to the countryside if agricultural livelihoods improved. In Senegal experts observe an increasing movement of people back to the countryside due to the global economic crisis. However, that coping mechanism is running into counter-pressures because areas people are returning to are in many cases already degraded. Conflict over access to land seems to be increasing.[67]

Some farmers do manage to find alternative livelihoods that allow them to return home. In Niger, a returned migrant from the village Talcho, Filingue (Tilabéri, Niger) remarked, "I lost hope in producing crops, since the soil got too poor due to the droughts. I used to be a farmer in my home town. Therefore I first went to Lomé (Togo) and then Libya. Now, I have decided to return back to Niger where I will start a new business with the money I managed to collect in Libya."[68]

Rather than returning after migrating, the trend goes in the opposite direction.[69] People increasingly migrate step-by-step in pursuit of environments that will support them. The residents of the village Caré in the Tilabéri region of Niger is now home to migrants from another village called Farka where soil degradation has made crop cultivation impossible. A migrant remarked: "We were farmers in Farka, but the production level worsened too much and the harvest got completely unreliable due to the rain fall shortage and soil degradation. We had no alternative revenues. Therefore, we had to flee this village in the year 1987…there is no other reason why we left the original village; if this deterioration in the land quality had not happened, we would have stayed. Currently in Caré we are suffering from similar problems and might therefore leave the village for another as well. We have never planned to leave, but we just ´crept´ after our living."[70]

In another study in Burkina Faso, researchers found that people from drier regions are more likely to migrate temporarily and to a lesser extent permanently to other rural areas (rural–rural migration), compared with people from wetter areas. A rainfall deficit increases the rural-rural migration but decreases migration to abroad. No rush to cities has been observed during periods of drought.[71] A fisherman in the village of Sirba (Tilabéri, Niger) recounts, "I have been suffering from the rain water shortage which made the river very shallow and decreased my fish production, which had negative implications on my income. If the situation does not improve, I might leave for another country like some of my friends and relatives did; they left for Nigeria and Burkina Faso and settled there."[72] Studies in other regions support this finding, and suggest that environmental conditions often play a more direct role in short-term moves rather than long-term ones.[73] And yet, if environmental changes render "home" unlivable, short-term migration can develop into a pattern of creeping onward movement.

Robert Ford of the Centre for GIS Training and Remote Sensing, National University of Rwanda noted, "Those of us living with these issues here in Africa are already seeing some major movements of people. In many parts of Africa, people living on the margin seem to quickly pick up signals that indicate whether on balance life is better by going to the city or returning to the land. That this much ferment is happening now, before climate change really hits, tells me that we had better get prepared."[74]

By the end of 2008, Sudan's internally displaced population had grown to 4.9 million, making it the largest in the world. More than 523,032 Sudanese have fled their country as refugees (UNHCR, June 2008). The causes of displacement and migration in Sudan are notoriosuly complicated. However, environmental change is broadly recognised as playing an important role.

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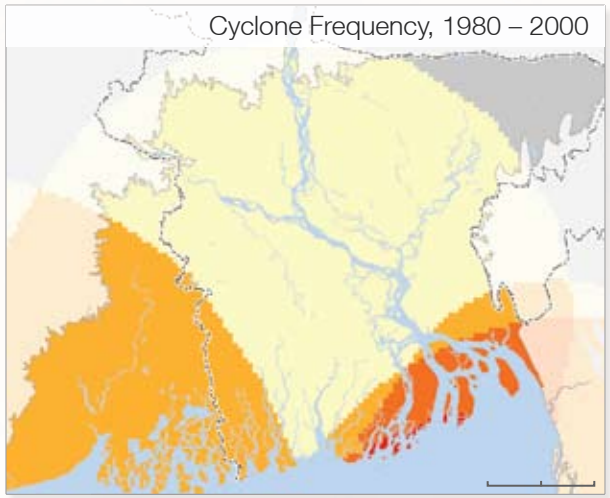
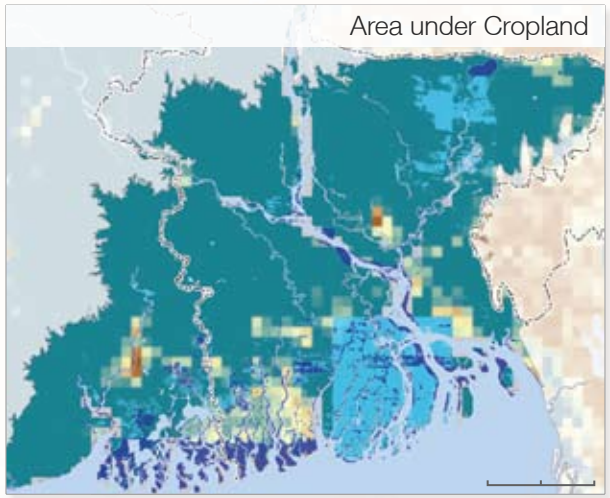
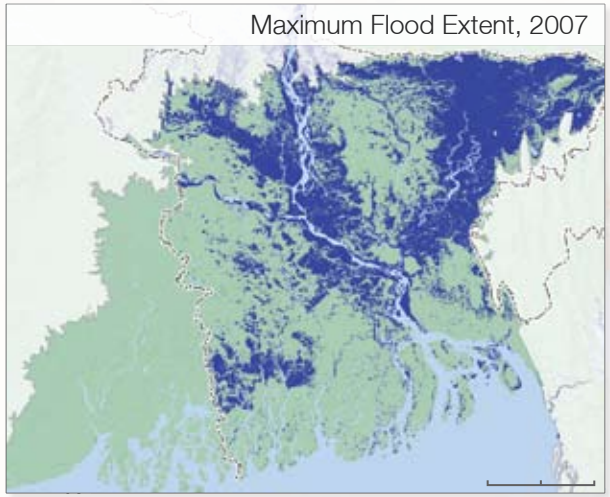
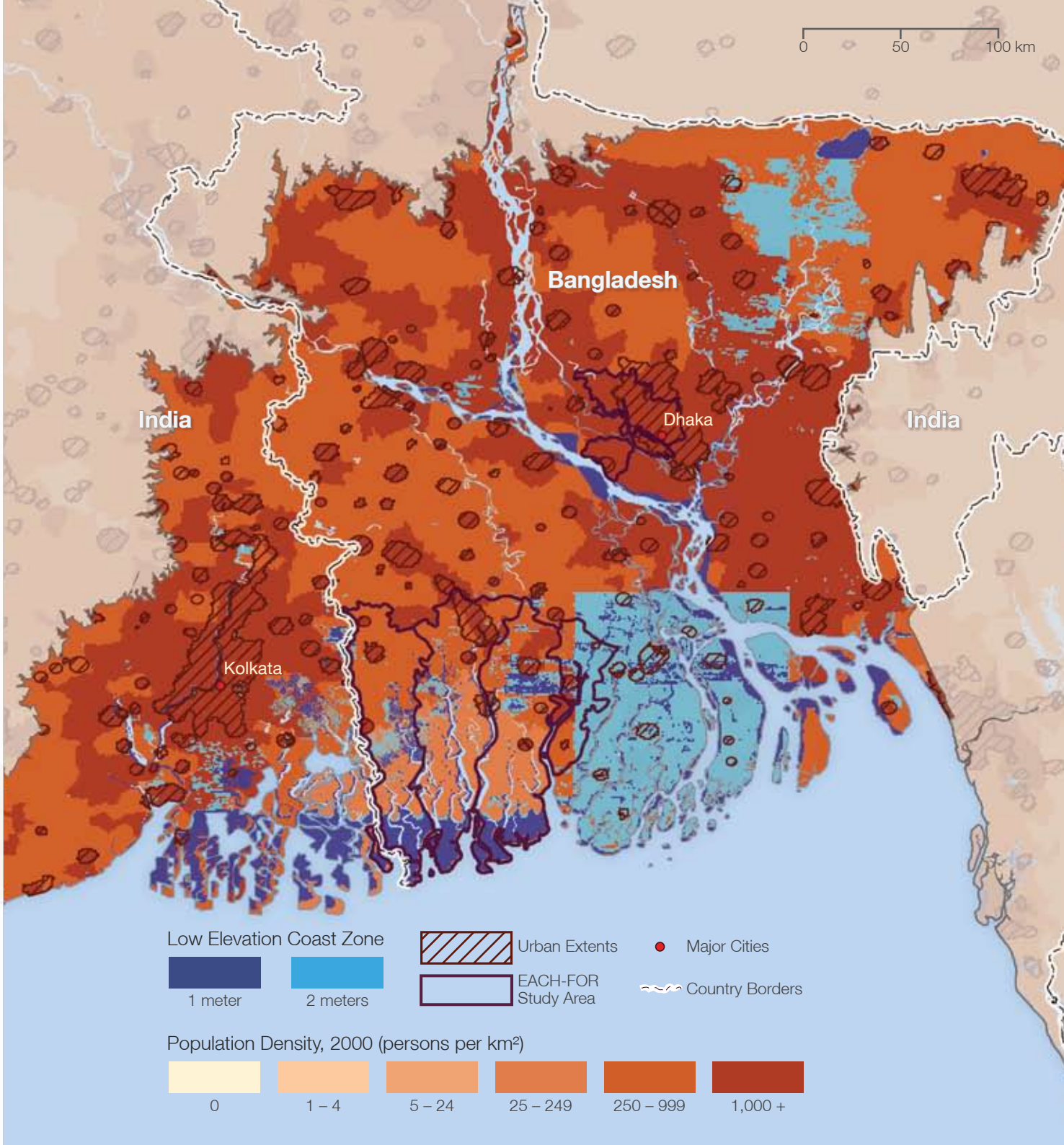

Cyclone Frequency, 1980 – 2000
High
Low


Area under Cropland
100%
0%
no data


Maximum Flood Extent, 2007
flood extent


0
50
100 km
Bangladesh
India
Dhaka
India
Kolkata
Low Elevation Coast Zone
1 meter
2 meters
Urban Extents
EACH-FOR Study Area
Major Cities
Country Borders
Population Density, 2000 (persons per km²)
0
1 – 4
5 – 24
25 – 249
250 – 999
1,000 +

3.4 The Ganges Delta: Temporary migration as a survival strategy

Including the Ganges, Bangladesh contains seven major and over two hundred minor rivers, all of which define the delta geography of Bangladesh and the way of life of its people. Bangladesh is one of the most densely populated countries in the world, and a large part of its people depends on natural resources for their livelihoods. Although flooding is a part of the livelihood structure and culture, climate change will accelerate change in this already dynamic environment and leave millions of Bangladeshis exposed to increased flooding, severe cyclones, and sea level rise impacts.[75]

More than 5 million Bangladeshis live in areas highly vulnerable to cyclones and storm surges, and over half the population lives within 100 km of the coast, most of which is less than 12 meters above sea level.[76] Flooding currently displaces about 500,000 people every year. In 2007, two extreme weather events devastated the country: Flooding caused 3,363 deaths and affected 10 million people as well as reducing crop yields by 13 percent. Just months later, Cyclone Sidr destroyed 1.5 million houses, large areas of cropland and mangrove forests, and affected 30 out of 64 districts in the country. Millions experienced food insecurity (monga) and required evacuation, shelter and relief assistance.[77] As devastating as these cyclones were, early warning systems were successful in preventing the deaths of many thousands more. In 1970 a cyclones caused the deaths of an estimated 300,000, and in 1991 another 140,000 died.[78]

The Bangladesh EACH-FOR case study found that flooding and bank erosion are a complex mix of natural and socioeconomic processes contributing to population displacement.[79] Combined with sea level rise, storm surges linked to cyclones could temporarily inundate large areas of Bangladesh—one study suggested that up to 25 percent of the country could experience such a scenario.[80]

Temporary migration linked to flooding and other disasters, frequently to Dhaka and other urban centers, is viewed as both a coping and survival strategy to escape riverbank erosion, the devastation of cyclones, and food insecurity. Almost all areas in Bangladesh are densely populated and under cultivation, and many locations are vulnerable to similar environmental risks. There are no guarantees of finding employment or housing in the place of destination.

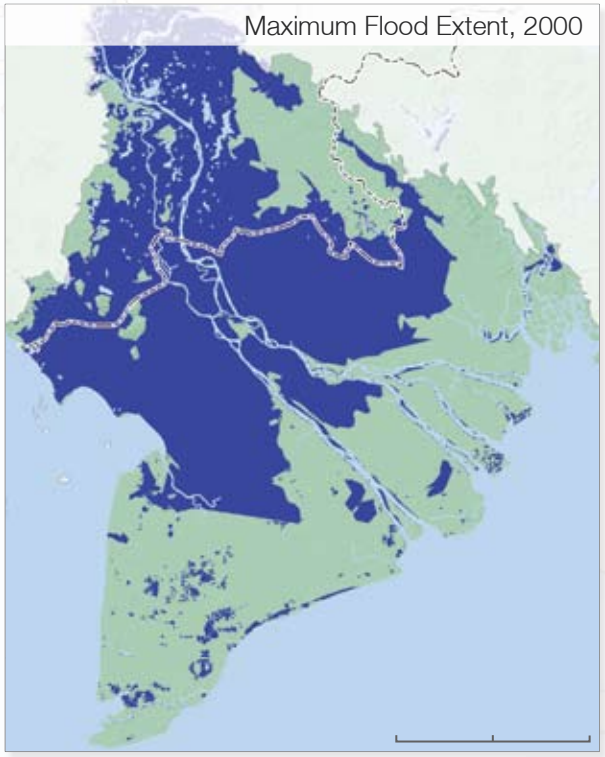
For coastal fishing villages, cyclones, storm surges, and sea level rise pose a formidable adaptation challenge. One fisherman interviewed by a journalist during the 2008 cyclone season noted, "The sea has been coming closer and closer," then added in Bengali, "Allah jane ke hobe. Sahbi shesh ho jabe." [God only knows what will happen. Everything will come to an end.] In spite of accelerated erosion related to stronger and higher tides, villagers are determined to stay and pursue their livelihoods as long as possible. The same journalist interviewed another fisherman who said, "We can´t do anything else, which is why we think twice about migrating from here. We know the end is coming, but what work will we find to feed our families elsewhere?"[81]

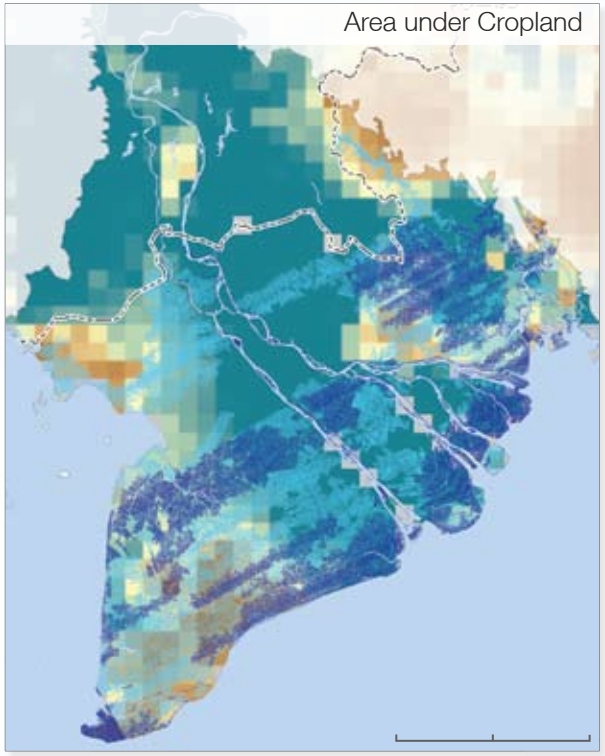
Even if the causes of migration are similar from one person to the next, people opt for different strategies in terms of destination and timing of migration. But there might be a moment when they will not be able to adapt any more. In 20 or 30 years Bangladesh may see mass movement of people from flood-prone areas, possibly to urban centers. The current structures and organizations to help the victims of disasters will not be enough to cope with the increase of migration flows in the future. Given the political instability of the region, population movements associated with climate change could become an issue for regional security.

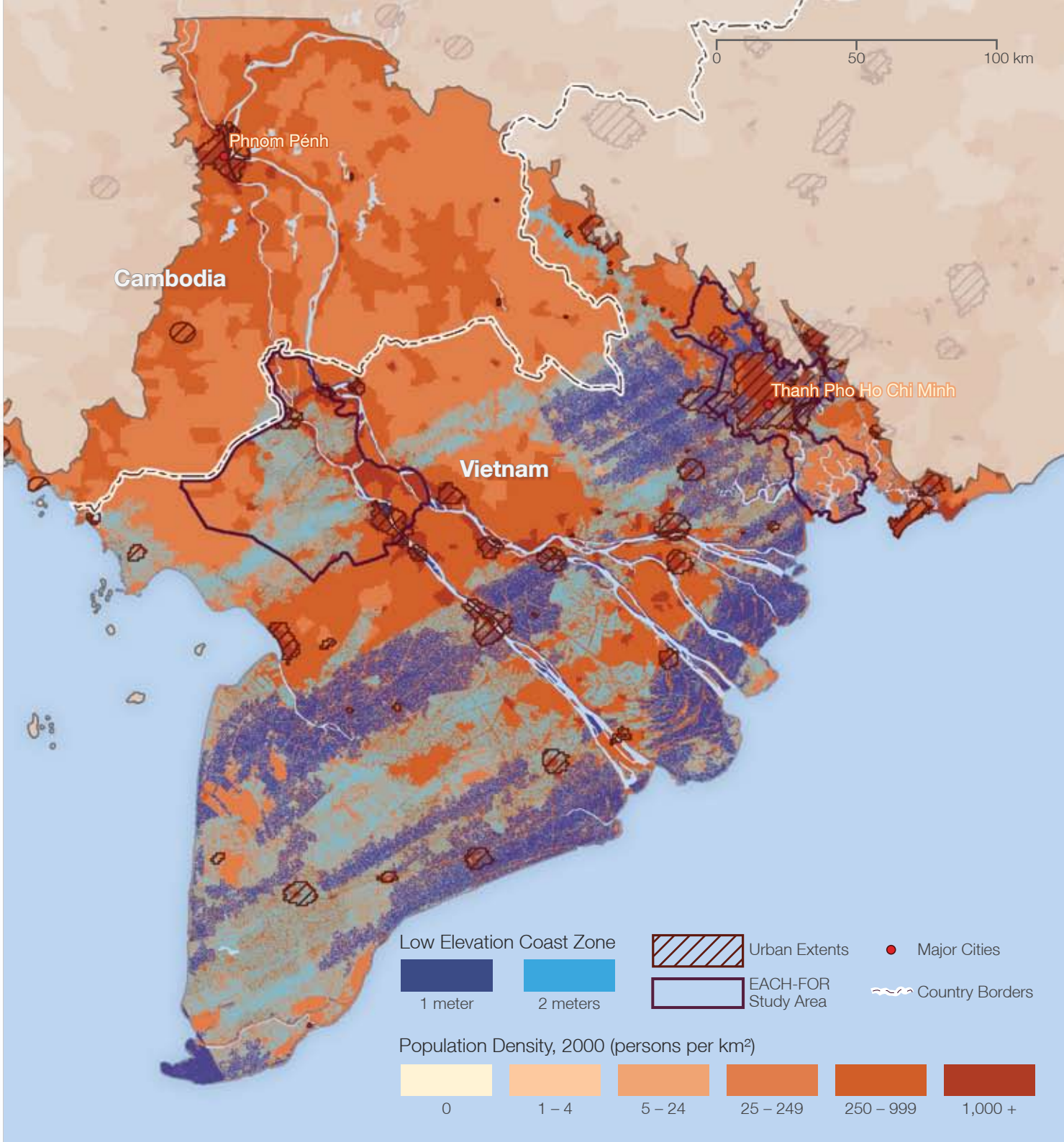
However, adaptation strategies could reduce the environmental vulnerability and increase the resilience of local populations. EACH-FOR research suggests that the population is already working to adapt to the new situation, mainly by leaving agriculture for other livelihoods such as shrimp farming.[82] The worsening of the environmental situation in the Ganges delta, however, could render migration as one of the most realistic options available for some Bangladeshi people.

What does this map tell us?

The main map depicts areas of sea-level rise at 1 and 2 meters (dark and light blue, respectively) on a population density map with urban extents delineated. Note that there are "tiling effects" in the elevation data that make the area around the main stem of the Ganges to appear to abruptly change elevation. The map also shows the regions of the EACH-FOR study areas in the lower delta. The Ganges delta supported a population of 144m in 2000, out of which at least 10m live in areas that would be inundated by a 2m sea-level rise. The upper left hand inset map shows those areas most frequently impacted by tropical cyclones. Low elevation areas in the southeastern corner of the delta are most affected. The inset map below it shows the distribution of agricultural lands. The delta has 8 million ha of agricultural lands, of which at least 200,000 ha would be inundated by a 2m sea-level rise. In the Ganges Delta, living with varying water levels is a way of life. Migration, particularly towards coastal urban centers, has emerged as a coping mechanism when extreme events endanger life and livelihoods. With projected sea level rise, combined with the possibility of more intense flooding, migration may become necessity for many communities, at least for parts of the year.


Maximum Flood Extent, 2000
flood extent


Area under Cropland
100%
0%
no data


0
50
100 km
Phnom Pénh
Cambodia
Thanh Pho Ho Chi Minh
Vietnam
Low Elevation Coast Zone
1 meter
2 meters
Urban Extents
EACH-FOR Study Area
Major Cities
Country Borders
Population Density, 2000 (persons per km²)
0
1 – 4
5 – 24
25 – 249
250 – 999
1,000 +

3.5 The Mekong Delta: Living with floods and resettlement

Environmental degradation, particularly impacts caused by flooding, is a contributing factor to rural out migration and displacement in the Mekong Delta of Vietnam. The Vietnamese portion of the Mekong Delta is home to 18 million people, or 22 percent of Vietnam´s population. It provides 40 percent of Vietnam´s cultivated land surface and produces more than a quarter of the country´s GDP. Half of Vietnam´s rice is produced in the Mekong Delta, 60 percent of its fish-shrimp harvest, and 80 percent of Vietnam´s fruit crop. Ninety percent of Vietnam´s total national rice export comes from the Mekong.

Flooding plays an important role in the economy and culture of the area. People live with and depend on flood cycles, but within certain bounds. For example, flood depths of between half a meter up to three meters are considered part of the normal flood regime upon which livelihoods depend. These are so-called "nice floods" [ngâp nông] by Vietnamese living in the delta, such as upstream in the An Giang Province. Flood depths beyond this such as between three and four meters [ngâp vùa], however, challenge resilience capacities of affected people and often have harrowing effects on livelihoods.

Floods exceeding the four meter mark, called "ngâp sâu" for severe flooding, have increased in magnitude and frequency in Vietnam in recent decades.[83] In Phnom Penh (Cambodia) one migrant from the Delta noted, "Flooding occurs every year at my former living place. I could not grow and harvest crops. Life therefore was very miserable. Besides, my family did not know what else we could do other than growing rice and fishing. Flooding sometimes threatened our lives. So we came here to find another livelihood."[84]

Another migrant said, "My family had crop fields but in recent years, floods occurred very often so the crop was not stable. In addition, the price of fertilizer increased very fast, and the diseases of the rice plant are too much, so the crop yield was nothing. Even sometimes the yield was not enough to cover the amount required for living."[85]

"Natural hazards, in combination with the stress placed on the environment due to rapid socioeconomic development within Vietnam and upstream South-east Asian countries, overlaid with the threats posed to Vietnam by climate change, places Vietnam's natural resources and those who depend upon them for their livelihoods in a precarious position. In the face of environmental stressors, people in the Mekong Delta adapt in various ways. One type of adaptation mechanism may be migration, particularly in light of the rapid socio-economic changes that Vietnam is currently experiencing, which create stronger pull factors towards urban environments".[86]

Fieldwork from the EACH-FOR project indicated that lack of alternative livelihoods, deteriorating ability to make a living in the face of flooding, together with mounting debt, can contribute to the migration "decisions" in the Mekong Delta. People directly dependent on agriculture for their livelihood (such as rice farmers) are especially vulnerable when successive flooding events destroy crops. This can trigger a decision to migrate elsewhere in search of an alternative livelihood. During the flooding season, people undertake seasonal labor migration and movement towards urban centers to bolster livelihoods. As an extreme coping mechanism, anecdotal information from fieldwork pointed to human trafficking as one strategy adopted by some families who have suffered from water-related stressors.

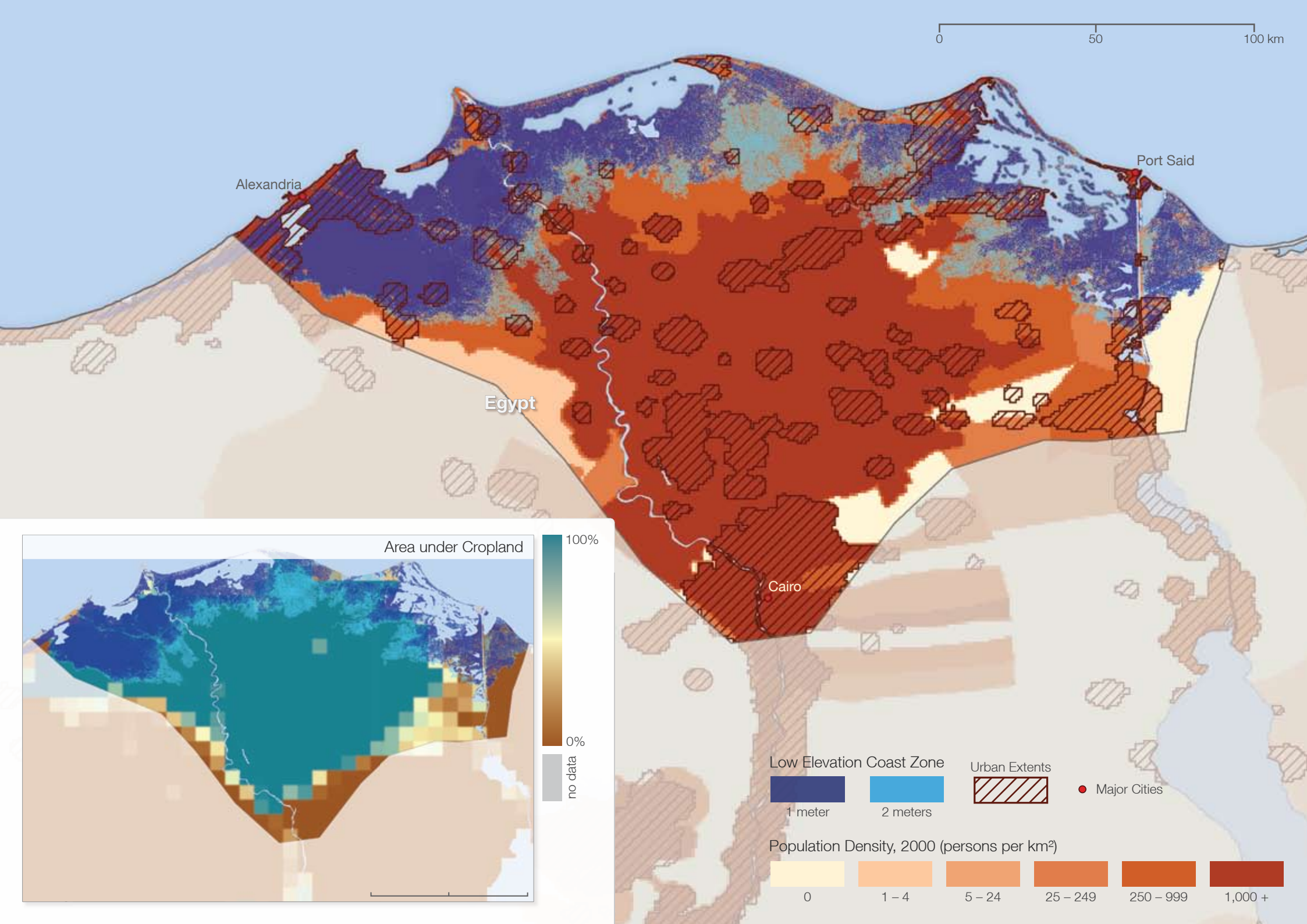
A migrant interviewee referred to the financial vulnerability of her family related to flooding, "Disasters occurred so often - my family lost the crop, my family had to borrow money to spend. Now, my family is not able to pay off the loan so I have to come here to work to help my family to pay the loan."[87]

The government in Vietnam has a program known as "living with floods."[88] This program may become more important as the impacts of climate change become more pronounced. The government, as part of this flood management strategy, is currently resettling people living in vulnerable zones along river banks in the An Giang province.[89] Almost 20,000 landless and poor households in this province are targeted for relocation by 2020. Households are selected for resettlement based on a number of factors related to the environment, such as living in an area at risk of natural calamities (flooding, landslides) or river bank erosion. These resettlement programs allow families to take up a five year interest free loan to enable them to purchase a housing plot and basic house frame. Households then often need a further loan to complete building the house.[90] The clusters provide few infrastructure services like access to schools, health, or water and sewage treatment facilities.[91] People planned for relocation are usually the landless who have nowhere else to move if their houses collapse and are often too poor to move to urban areas. For these people, social networks provide the link to livelihoods—most rely on day-to-day employment as laborers. Although the "residential clusters" are usually located only 1–2 kilometers away from the former residence, moving people out of established social networks threatens their livelihoods and contributes to a sense of isolation. The resettlement clusters are not yet planned in a way that allows participation of potential residents.

The Vietnamese strategy of "living with floods" will combine resettlement, shifting livelihoods (i.e. from rice to fishery-based jobs), and some migration. In the future one out of every ten Vietnamese may face displacement by sea level rise in the Mekong Delta.[92]

What does this map tell us?

The main map depicts areas of sea level rise at 1 and 2 meters (dark and light blue, respectively) on a population density map with urban extents delineated. It also shows the regions of the EACH-FOR study areas. The Mekong delta supported a population of 28.5 million in 2000, out of which 14.2 million lived in areas that would be inundated by a 2m sea level rise. The upper left inset map shows the area flooded in the year 2000 when unusually widespread monsoon floods deluged nearly 800,000 sq. km of land in Cambodia, Vietnam, Thailand, and Laos. The inset map below it shows the distribution of agricultural lands. The delta has 3 million ha of agricultural lands, of which 1.4 million ha would be inundated by a 2 meter sea level rise. Resettlement programs are already underway in some areas of the delta, and could become more widespread under certain sea level rise scenarios.


0
50
100 km
Alexandria
Port Said
Egypt
Cairo
Area under Cropland
100%
0%
no data
Low Elevation Coast Zone
1 meter
2 meters
Urban Extents
Major Cities
Population Density, 2000 (persons per km²)
0
1 – 4
5 – 24
25 – 249
250 – 999
1,000 +

3.6 The Nile Delta: Between desertification and sea level rise

In Egypt slow-onset events like sea level rise and desertification affect the Nile Delta.[93] The total area of the Arab Republic of Egypt is about one million km², most of which has an arid and hyper-arid climate. The most productive zones in Egypt are the Nile Delta and Nile Valley (3 percent of the total land). Projected increases in sea levels will pressure a quickly growing population into more concentrated areas. Desertification and soil degradation claim large swaths of land on the Eastern and Western Nile Delta. Large swaths of land may be rendered unusable by the dual climate change-related forces of desertification and sea level rise. In the future, sea level rise could affect an additional 16 percent of the population.[94]

The overall area influenced by the active encroachment of sand and sand dunes is estimated to be roughly 800,000 hectares.[95] Land productivity has diminished by about 25 percent compared to its original productivity.[96] The annual erosion rate has been estimated between 0.8 and 5.3 ton/ha/year.[97] Desertification and land degradation drive some people to migrate internally in search of livelihoods.

The government of Egypt combats desertification through an internal migration scheme related to the Mobarak National Project in the Western and Eastern Delta. The program was initially designed to alleviate environmental programs but also unemployment, poverty, and overpopulation in Cairo, Beheira, Kafr El-Sheikh, and Qalioubia. This project aimed to create an internal urban-to-rural migration flow towards the edges of the Delta.

People who were resettled in the Eastern Delta were mainly unemployed young men from urban slums. In contrast, the people who moved to the Western Delta were mainly farmers affected by a law that favored land owners who could easily drive away share croppers from desirable agricultural areas. After eviction, the share croppers were moved by the government to the Western Delta.

The program allocated each sharecropper/farmer in the Eastern and Western Delta a land parcel of 10,500m², and often additional migrants came to work as peasants in these areas. Soon, however, reclaimed areas began to manifest soil and water salinity problems. When it became too expensive to dig new wells for groundwater, many landowners sold their land and evicted the migrant peasants. One farmer remarked, "When I left my original village called Bassioun-Gharbia in Mid-Delta, I started working in a newly reclaimed land in the desert. After a while the land was affected by the problem of ground water salinity. The owner of the land decided to sell the land…I had to leave the land and then I came here to Embaba, a desert location in Western Cairo."[98] The new immigrants received shelter and agricultural extension and veterinary services from the government and NGOs. Government funding provided migrants with pesticides and artificial crop pollination. Yet initial investments and incentives to encourage poor people to migrate to new areas tapered off with time. The Western and Eastern Delta lack access to potable water, proper infrastructure, public facilities, schools, health care, and well-functioning sewage systems. Consequently, many migrants did not stay and others are expected to leave either to other regions or to return to their original regions. Today, only half of designated resettlement land has been utilized.

With the dual processes of sea level rise and desertification, the question arises where people in the densely-populated Nile Delta will go? EACH-FOR research suggested that many people do not want to migrate away from their lands of origin. One interviewee living along the Nile River noted, "I would have a reason to move because of the water shortage and soil degradation…and crop yields are declining. However, I cannot leave my land. I have inherited this land from my father a long time ago and cannot just leave it. I got used to the place, I have my big family and my friends here. I have never left this place, I have never gone to Cairo before, so how shall I simply leave it now and migrate to somewhere else? We will have to economize in our consumption and hope that things will get better."[99]

What does this map tell us?

The main map depicts areas of sea level rise at 1 and 2 meters (dark and light blue, respectively) on a population density map with urban extents delineated. It also shows the boundary of the Nile delta. The Nile delta supported a population of 40.2 million in 2000, of which 10.7 million lived in areas that would be inundated by a 2 meter sea level rise. The inset map shows the distribution of agricultural lands. The delta has 1.5 million ha of agricultural lands, of which 518 thousand ha would be inundated by a 2 meter sea level rise. These processes could compress people into a smaller livable area and contribute to deteriorating living standards.

3.7 Tuvalu and The Maldives: Sea level rise and small island developing states

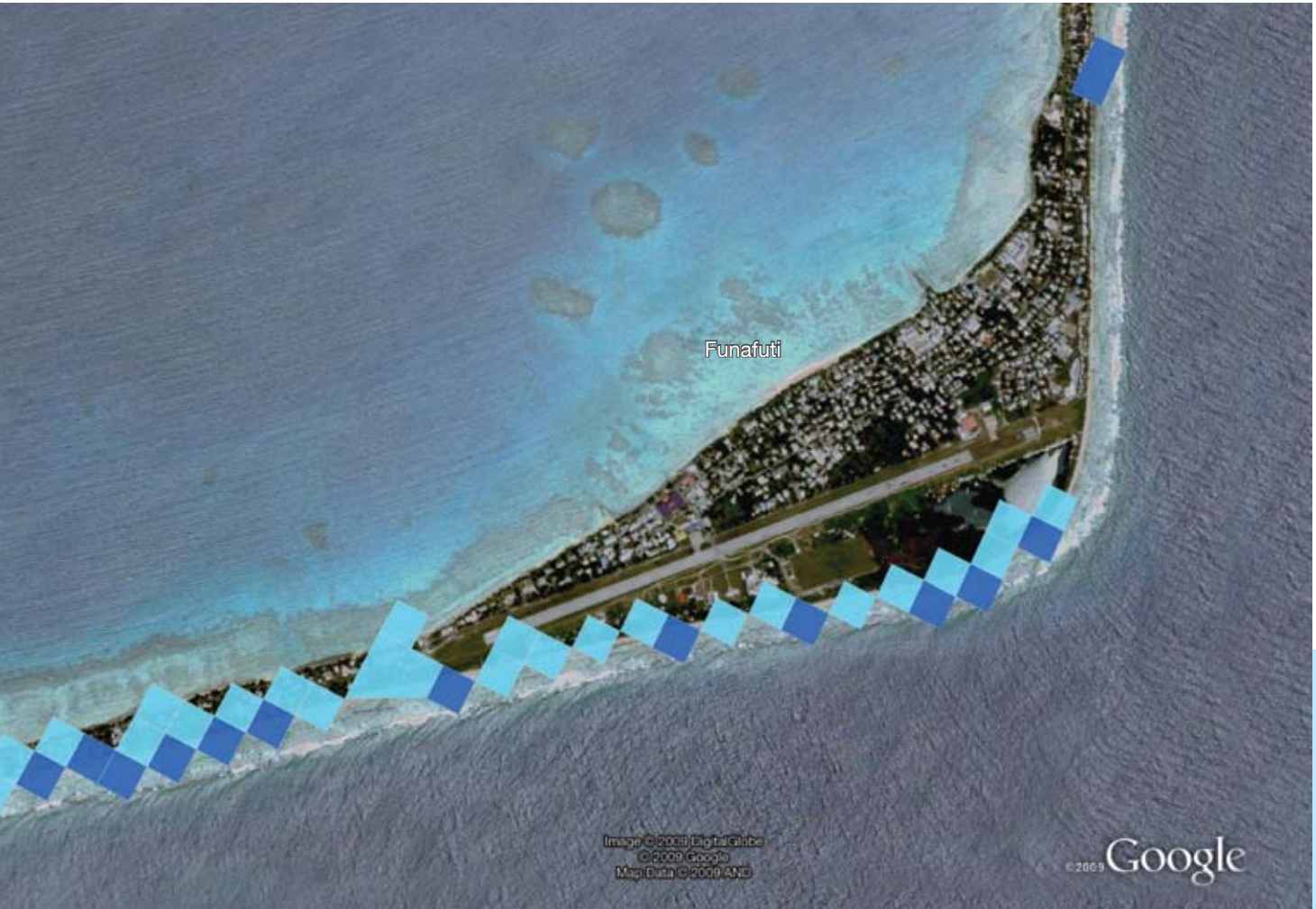
Small island states are particularly vulnerable to sea level rise due to climate change. According to the IPCC:

> *Sea-level rise is expected to exacerbate inundation, storm surges, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. (…) There is strong evidence that under most climate change scenarios, water resources in small islands are likely to be seriously compromised. (…) Climate change is likely to heavily impact coral reefs, fisheries and other marine-based resources. (…) It is very likely that subsistence and commercial agriculture on small islands will be adversely affected by climate change.*[100]

Tuvalu

As one of the smallest and most remote low-lying atoll countries on earth, Tuvalu exemplifies a country whose existence is threatened by sea level rise. Tuvalu´s territory covers over 750,000 km2, yet only 26 km2 is dry land with no point more than 5 meters above high tide.

Its low elevation makes Tuvalu highly vulnerable to sea-level rise, storm surges, "king tides", and other climatic events which affect the entire population of the country (all Tuvaluans live on the coastline). Tuvalu's environmental problems are further compounded by water shortage, waste disposal and demographic pressures. Local knowledge of global warming is variable, but increasingly frequent saltwater flooding, accelerated coastal erosion and worsening agriculture provide day-to-day evidence of a changing environment. The adaptive capacity of many Tuvaluans is already exceeded with storm surges and king tides. With the possibility of sea level rise of one meter this century, even if the surface area is not completely submerged, the question arises how long people there can remain and lead normal lives.



Migration patterns in Tuvalu follow two paths: from outer islands to Funafuti, and from Tuvalu to Fiji and New Zealand. Currently about 3,000 Tuvaluans have migrated to Auckland, New Zealand, many of whom were prompted at least in part by concerns about the environment. One interviewee noted his decision to migrate is out of fear that Tuvalu will be flooded: "I don´t want to wake up one morning with the island washed away. Look at what happened in the Solomon Islands! I prefer to leave now before I have no other choice."[101]

Uncertainties about the future seem to be pre-eminent migration drivers, even more than actual environmental concerns. Almost all migrants interviewed in New Zealand indicated that climate change and rising sea levels had contributed to their decision to migrate. All interviewees noted a concern that their country could be inundated permanently. One migrant noted, "When I left, it was clear that it would be getting worse year after year…I return once a year, because I still have family in Tuvalu. Maybe they´ll come as well to New Zealand, one day. That depends on how bad it gets. (…) I don´t know if Tuvalu will disappear or what (sic), but I don´t think people have a future in Tuvalu, it's going to get worse."[102]

Although media reports have suggested a nation-wide resettlement agreement made between New Zealand and Tuvalu, currently there are labor migration agreements with New Zealand, but not explicit policies to accept Pacific Islanders who

What do these maps tell us?

These maps depict the areas of the capitals of Tuvalu (Funafuti) and the Maldives (Malé) that will be affected by a 1m (dark blue) and 2m (light blue) sea level rise. Low lying islands face multiple challenges of development, storm surges and cyclones, coastal erosion, and the specter of sea level rise. For some 40 small island

have been displaced due to rising sea levels. Interviews from fieldwork revealed mixed views on migration, ranging from the most common perception of resignation and despair, to hope that the international community will rally to effectively battle climate change and prevent sea level rise and other harrowing consequences. Some believe that climate negotiations that set aside sufficient adaptation financing could preempt a need to migrate due to changing climate and sea level rise:

> *"The international community needs to do something to help us. We´re not responsible for climate change, so our country cannot disappear. The other countries need to fix this problem."*[103]

Since Tuvalu joined the United Nations in 2000, it has played an active role in the Association of Small Island States (AOSIS), and has used international fora like the climate negotiations to attract the world´s attention to the specific vulnerabilities of small island states and the need to identify acceptable adaptation alternatives in good time.

The Maldives

The Maldives is an atoll country comprised of 1,200 islands and 298,968 inhabitants in 2006.[104] Its highest point is 2.3 meters above sea level, and it is considered the lowest laying country in the world. Male, the capital city, holds 35% of the country's population and is one of the most densely populated cities on earth. The city is surrounded by a 3.5 meters high sea wall,[105] credited with saving the capital from the 2004 Tsunami.[106]

As indicated in the map, a sea level rise of one meter would inundate infrastructure and threaten living areas. This would pose a threat to the tourism industry that comprises the most important income source for the Maldives, but this is not the only risk. Maldives' government has identified a number of vulnerabilities: land loss and beach erosion, infrastructure and settlement damage, damage to coral reefs, agriculture and food security, water resources, and lack of capacity to adapt (both financial and technical).[107] The newly elected president of the Maldives, Mohamed Anni Nasheed, made international headlines in 2008 when he announced the "Safer Islands Plan" which includes internal resettlement from smaller, less populated islands to larger islands with better natural protection and enhanced coastal defenses. The plan even addressed the possible relocation of all the Maldives population to another country such as India or Iceland.

Permanent Representative of the Maldives to the United Nations, H.E. Ahmed Khaleel noted, "Migration and resettlement from smaller to larger islands has become an important prerequisite for development and for our survival."[108]

To find adaptation alternatives for the approximately forty countries whose existence is threatened by rising sea levels, international cooperation and assistance is needed. One researcher at the recent climate negotiations in Poznan, Poland (COP 14) noted, "So few of the migrants we encountered in our fieldwork worldwide were able to migrate internationally—the vast majority face a situation where they 'only make it' to the next livable place. This will increasingly require countries to work together, especially developing countries".[109]

developing states, sea level rise could submerge entire parts of sovereign nations. The process of resettlement may in the long run be a central adaptation measure. Yet if entire sovereign states are submerged by rising seas, resettlement poses significant geopolitical questions and highlights the need for effective international cooperation.

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*Since 2004, CARE has been working with villagers in southern Bangladesh to help them adapt to increasingly intense and frequent flooding. Activities include the creation of "floating gardens" that rest on a bed of water hyacinth (*eichornia crassipes*). Buoyed by the hyacinth, crops can rise above the flood waters to protect a critical source of food and income.*

4. Conclusions

Climate change is happening with greater speed and intensity than initially predicted.[110,111] Safe levels of atmospheric greenhouse gases may be far lower than previously thought, and we may be closer to an irreversible tipping point than had been anticipated.[112] Meanwhile, global CO2 emissions are rising at steeper and steeper rates.[113] Emissions reductions efforts have been too little, too late. Therefore, the challenges and complex politics of adaptation are joining those of mitigation at the centre of policy debates. One of the most important issues to address is how climate change will affect human migration and displacement—and what we will do about it.

There are many messages to be taken from the empirical evidence and maps presented in this Report. The following are especially important:

Environmental change, displacement and migration

The reasons why people migrate are complex but frequently reflect a combination of environmental, economic, social, and/or political factors. The influence of environmental change on human mobility is discernible and growing. Current and projected estimates vary widely, with figures ranging from 25 to 50 million by the year 2010 to almost 700 million by 2050. The International Organisation for Migration (IOM) takes the middle road with an estimate of 200 million environmentally induced migrants by 2050.

Livelihoods and human mobility

Environmental change is most likely to trigger long-term migration when it undermines the viability of ecosystem-dependent livelihoods (such as rainfed agriculture, herding and fishing) and there are limited local alternatives. The degradation of soil, water and forest resources, as well as the direct impacts of climate change (e.g. shifting rainfall), are playing important roles in emergent patterns of human mobility.

Differential vulnerability

People's vulnerability to environmental change reflects a combination of their exposure, sensitivity and adaptive capacity. As a result, degree of vulnerability varies widely within countries, communities and even households. For instance, poor people's exposure to the impacts of climate change is often higher than others because economic and political forces confine them to living in high-risk landscapes (e.g. steep hillsides prone to slippage). Meanwhile, one of the most important factors shaping adaptive capacity is people's access to and control over natural, human, social, physical, political and financial resources. Their striking lack of these things is a major reason why poor people —especially those in marginalised social groups—are much more vulnerable to the impacts of climate change than others.

Women contend with an especially wide array of constraints on their adaptive capacity. Gendered roles, as well as cultural prescriptions and prohibitions, make it far more difficult for most women and female-headed households to migrate in response to environmental change.

Government action and risks

Some forms of environmental change, including sea-level rise and glacier melt, may require large-scale government action. However, interventions can leave people no better off, or even worse, than before. As described in section 3.3 of this report, for instance, the government of Vietnam is currently relocating some people living in areas threatened by riverbank erosion, flooding and storm surges. Though the intention is commendable, resettlement can carry high costs including cultural degradation, lost livelihoods, reduced access to social services, and the loss of employment networks. In sum, top-down responses to environmental change carry substantial risk, including the risk of "mal-adaptation."

The importance of inclusive, transparent and accountable adaptation processes

The scale of current and projected environmental changes necessitates a crucial role for central governments. Yet we have learnt from experience that benefits can be maximised and risks minimised if vulnerable populations are meaningfully involved in the planning, implementation, monitoring and evaluation of coordinated responses to environmental change.

This points towards one of the most important conclusions to draw from this report. Namely, that the scope and scale of challenges we face may be unprecedented; but we meet them already having many of the resources—including knowledge, skills and relationships—needed to protect the dignity and basic rights of persons threatened by displacement from environmental change.

End Notes

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Fieldwork

The extent of human-induced environmental degradation has been documented in a wide range of publications. The most commonly discussed environmental change resulting from human activities is climate change, but there are many other signs of environmental change, including soil fertility depletion, deforestation, and desertification. At the same time, humans face massive social, political, and economic changes today as a result of globalization and technological change.

Although there is substantial information about environmental change, natural hazards, migration, and economic development, systematic empirically- based knowledge about the links between environmental change processes and migration remains scarce. To help fill this gap, the European Commission funded the Environmental Change and Forced Migration Scenarios Project (EACH-FOR) to explore the role environmental changes play in shaping migration decisions. This was done through the systematic overview and analysis of relevant natural and human-made environment degradation processes, as well as the socio-economic and demographic contexts in the regions studied in the project. The project undertook fieldwork in twenty-three sites around the world.

Mapping

The maps in this report represent the integration, at scales ranging from continental to small islands, of geospatial datasets such as population (size, density, and distribution), hydrology (Asian river basins, highly populated river deltas), projected sea level rise (1 and 2 meters), agriculture (rain-fed agricultural land and areas in pasture), projected changes in runoff, and cyclones. These databases were compiled from different sources and integrated using GIS techniques. Calculations of populations at risk were made using zonal statistics. More information about data sources and methodologies used can be found below.

This superimposing of populated areas and current and projected environmental hazards seeks to provide an initial identification of populations and livelihoods potentially at risk of climate change impacts. This first "layer" of vulnerability[114] could be considered part of the context that shapes migration decisions to a greater or lesser extent.

Data sets

A list of data sets utilized in map production is found below. One issue that needs to be addressed wherever climate change projections are employed is which models and scenarios to use, and what specific variable (e.g. temperature or precipitation) is of greatest interest. While recognizing that changing temperatures will have wide-ranging ramifications for many tropical and sub-tropical regions, especially where temperatures may exceed tolerances for specific crops, we felt that precipitation change is likely to have greater impacts on livelihoods.

Once that decision was made, additional choices presented themselves. In the maps presenting drying trends, we chose to use data on projected changes in runoff by Nohara et al (2006) published in the IPCC Fourth Assessment Report (AR4), Working Group 2 Synthesis report. These data were produced using an ensemble of climate models, and correspond broadly to the pattern of changing precipitation minus evaporation found in other ensemble modeling approaches.[115] Ensembles are generally more reliable than single model runs, since they average out the extremes. Runoff change was chosen rather than change in precipitation alone, or precipitation minus evaporation (P-E), because runoff represents the water that is effectively available for a range of human purposes, including crop growth and irrigation, and also for aquatic ecosystems, which are important for freshwater fisheries. However, as stated, whether one uses runoff or P-E, the patterns are broadly similar: (1) wet areas are getting wetter; (2) dry areas are getting drier; and (3) subtropical dry zones are expanding poleward.

In terms of sea level rise, the IPCC AR4 projected potential eustatic (meaning produced by the melting glaciers rather than thermal expansion) sea level rise of 0.8–1m this century. However, recent research suggests that the upper bound for sea level rise may be closer to 2m.[116] For this reason, we provide 1m and 2m bands for each delta area represented in section 4.3.

The following provides details on the data sets used for the maps in this report and, where appropriate, the methods for making map calculations:

Map 1: Glacier melt and major irrigated agricultural systems in Asia

This map combines glacier data from Armstrong et al. (2009) with river networks from ESRI (2008) and irrigated areas from FAO (2007) and FAO & IIASA (2006). Watershed boundaries (drainage basins) are from USGS HydroSHEDS 2007 (Lehner et al. 2006). Urban extents, representing circa 1995 urban areas, are from CIESIN (2009a).

Areas under irrigation and population totals for the different drainage basins dependent on glacier runoff were derived by compiling zonal statistics based on a grid of each drainage basin using Spatial Analyst in ArcMap 9.3.

Map 2: Mexico and Central America: Migration as a Coping Strategy for Drought and Disaster

This map combines runoff change data from Nohara et al (2006) that were used in the IPCC's Fourth Assessment Report. The population density map is from CIESIN (2009b). The runoff data are from Fekete et al (2000). The suitability of rain-fed agricultural land is from FAO (2007). Cyclone hazard frequency is from CHRR et al (2005).

Map 3: West Africa: Pressure on Agricultural Livelihoods and Creeping Onward Migration

This map combines runoff change data from Nohara et al (2006) that were used in the IPCC's Fourth Assessment Report. The grid representing runoff change was "grown" using standard raster-based methods (each new grid was assigned the maximum value of adjacent grid cells) so that it extended to or beyond the coastline, for better visualization. The population density map is from CIESIN (2009b). The runoff data are from Fekete et al (2000). The suitability of rain-fed agricultural land is from FAO (2007). The data on the proportion of area in pasture land are from Ramankutty et al (2008). The pasture map represents areas where the proportion of pasture is 70 percent or higher.

Maps 4, 5 and 6: Flooding and Sea Level Rise in Densely Populated Deltas: Ganges, Mekong, and Nile

These maps combine the following data sets. Geographic representation of the delta areas (delta masks) are from

Kettner (2009). The population density map represents year 2000 population and is from CIESIN (2009b). Urban extents are from CIESIN (2009a). Data on sea level rise was developed from CGIAR's Shuttle Radar Topography Mission (SRTM) 90 meter data set (Jarvis et al. 2008), except in the case of the Ganges Delta, where this was supplemented with data from GTOPO30 by the US Geological Survey. GTOPO30 was added because of the large area under mangrove canopy that SRTM is unable to penetrate. The data on the proportion of area under crop land are from Ramankutty et al. (2008). Cyclone hazard frequency is from CHRR et al (2005).

For the Ganges map, we provide a map of flood extent for the 2007 flood from UNOSAT (courtesy of Einar Bjorgo and Luca Dell'Oro). For the Mekong map we provide an inset of flood extent for the year 2000 from the Dartmouth Flood Observatory (2006).

In order to produce estimates of the year 2000 population that would be affected by a 1 and 2 meter sea level rise, we created a delta grid from Kettner (2009), then we took the year 2000 population grid from CIESIN (2009c) and, using ArcMap 9.3's zonal statistics, we calculated zonal statistics for the population that fell within the mask for 1– and 2 meter sea level rise based on CGIAR's SRTM data (Jarvis et al. 2008).

Maps 7-8: Sea Level Rise and Small Island Developing Countries

Data on sea level rise was developed from CGIAR's Shuttle Radar Topography Mission 90 meter data set (Jarvis et al. 2008), and converted to KML. The images of the islands representing the capitals of the Maldives (Male) and of Tuvalu (Funafuti) were downloaded from Google Earth.

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