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Climate extremes and resilient poverty reduction

Development designed with uncertainty in mind

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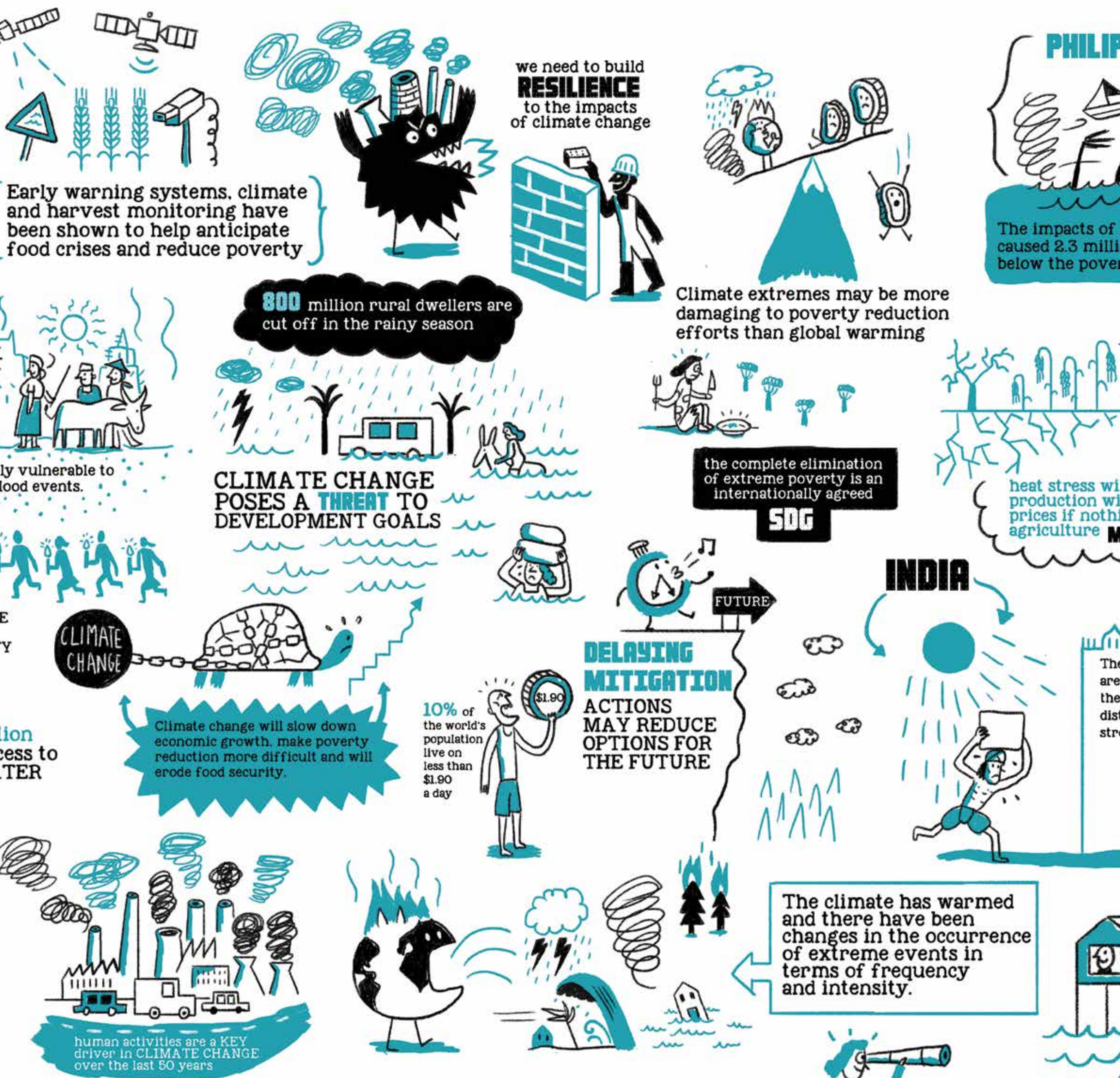

The BRACED Knowledge Manager

Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) aims to build the resilience of more than 5 million vulnerable people against climate extremes and disasters. The programme supports 108 organisations, working in 15 consortia, across 13 countries in East Africa, the Sahel and Southeast Asia. Uniquely, BRACED has a Knowledge Manager consortium led by the Overseas Development Institute (ODI) and includes the Red Cross Red Crescent Climate Centre, the Asian Disaster Preparedness Center, ENDA Energie, ITAD, Thomson Reuters Foundation and the University of Nairobi.

The Knowledge Manager vision is to: build knowledge and evidence of what works to strengthen resilience to climate and disaster extremes; get that knowledge and evidence into use, and; amplify knowledge and evidence beyond BRACED direct spheres of influence.

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Executive summary

Building resilience to climate extremes and disasters will help ensure the success of global efforts to eliminate extreme poverty. Reaching and sustaining zero extreme poverty, the first of the SDGs, requires a collective effort to manage the risks of current climate extremes and projected climate change.

1. Linking efforts to combat climate change and poverty

The global climate is warming and there is now growing evidence that climate variability is increasing in many places and extremes are becoming more frequent and intense in some parts of the world. Greater seasonal variability and changes in the prevalence and intensity of climate extremes pose serious challenges for poverty reduction in the future, both in terms of impact and the increased uncertainty that intensified climate risk brings.

Three major international frameworks will guide post-2015 action on climate change, disasters and development: the 21st Session of the Conference of the Parties (COP21) in Paris, the Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals (SDGs). Together with the 2016 World Humanitarian Summit, these provide an opportunity to join up efforts and address development and climate change challenges. For all of these frameworks to deliver, countries need to ensure their development trajectories don't maintain or exacerbate climate risks.

2. Examining climate extremes and resilient poverty reduction

This report explores the relationships between climate change and poverty, focusing on climate extremes, on the basis that these manifestations of climate change will most affect our attempts to reduce poverty over the next 15 to 25 years. Framed by a wider analysis, three detailed studies – on drought risk in Mali, heatwaves in India and typhoons in the Philippines – illustrate the relationship between climate change, climate extremes, disasters and poverty impacts.

All three case studies show the disproportionate impact of climate extremes on those living below the poverty line and those who suffer from non-income dimensions of poverty. Immediate impacts on poor households include loss of life (and associated loss of household earnings), illness, and loss of crops and other assets. Longer-term effects include increases in the price of staple foods, a reduction in food security, malnourishment, malnutrition and stunting in children, as well as lower educational attainment.

Indirect impacts are felt not only by poor households living in affected areas, but also by those in other parts of the country through drops in productivity and economic growth, loss of government assets, service disruption and the diversion of government spending to response activities. This supports the finding that there is no simple geographical co-location of climate extremes and poverty impacts: while there are some 'hotspots' around which to target interventions, such as in urban areas vulnerable to floods or storms, there are also significant knock-on effects on poor people elsewhere.

3. Implications for policy and planning

This report calls for improved resilience to climate extremes as a requisite for achieving poverty reduction targets. To achieve this, planners and policy makers will need to support the strengthening of the absorptive, anticipatory and adaptive capacities of communities and societies. New ways of working are required to link institutions that have previously been poorly connected, with new criteria for decision-making, such as considering the best solutions across different possible climate futures. The scale of the challenge suggests more transformative actions may be necessary, including through the use of new risk financing mechanisms.

Build adaptive, anticipatory and absorptive capacity

Tackling the combined challenges of poverty eradication and climate change requires action to increase the resilience of communities and societies most vulnerable to increasing climate risks. Capacity at the local level shapes how impacts of extremes play out and affect patterns of poverty. By building the anticipatory, absorptive and adaptive capacities of those communities and societies most vulnerable to increasing climate risks, we can minimise the impact of climate extremes on poverty levels and the poor.

Strengthen institutions, across scales

Continued investment in local disaster risk management capacities and institutions is required, as well as efforts to strengthen coordination across different levels of governance. Decentralisation can help empower local institutions and, when coupled with efforts to integrate local units within national and regional planning systems, it can produce more effective local solutions to the risks posed by climate extremes.

Think globally, but assess risk locally

While regional and global assessments are essential for understanding the scope of the climate challenge, local diagnosis is needed to provide a more accurate understanding of how risk is distributed. Analysis that connects macro-to-micro-scales, drawing on the comparative strengths offered at each level of analysis, will present a more nuanced and accurate picture of the climate change-disaster-poverty nexus.

Link institutions and solutions

Solutions that strengthen resilience and reduce poverty will need to link different institutions that have previously been poorly connected. Analysis of the relationship between climate change, disaster and poverty reveals some important gaps in connectivity and coordination across fields of policy and practice. More joined up ways of working across sectors and scales may be required, using climate and weather information, along with scenarios to inform planning.

The role of transformative action

Building resilience capacities incrementally may not be enough to secure poverty reduction in the face of climate change. The scale and scope of future climate risks will require a transformational shift in the way risk is managed. Transformational changes can be catalytic in nature, leveraging change beyond the initial direct activities. They achieve change at scale, with outcomes of a high order of magnitude relative to resource inputs, or can be sustainable over time, outlasting initial political and/or financial support.

Finance as a catalyst for transformation

Risk financing instruments have the potential to generate transformational changes by acting as a catalyst for further investment in disaster risk management and adaptation. Regional financing mechanisms can also help countries to scale up these investments in places where they are most needed. Finance is not a panacea and has limitations in some developing contexts, but it can and does offer opportunities for new ways to manage risk that warrant further attention as part of a portfolio of solutions.

Preface

There is a tendency to assume a strong overlap exists between places with high relative and absolute numbers of those in poverty and those that are most affected by climate extremes. The 2013 report The geography of poverty, disasters and climate extremes in 2030 mapped out where the poorest people are likely to live and found that many places with high numbers of poor will also experience increasing extreme weather events. The report concluded that up to 325 million extremely poor people will be living in the 49 most hazard-prone countries in 2030, the majority in South Asia and sub-Saharan Africa. It also estimated high levels of potential disaster-induced poverty by 2030 in countries such as Bangladesh, Democratic Republic of the Congo, Ethiopia, Kenya, Madagascar, Nepal, Nigeria, Pakistan, South Sudan, Sudan and Uganda. Yet, the picture at the sub-national level, where the impact of disasters is felt most acutely, is less clear. Within a country, levels of hazard intensity and frequency vary dramatically, as do people's exposure and vulnerability to different hazards. Hence the poverty impacts also vary geographically.

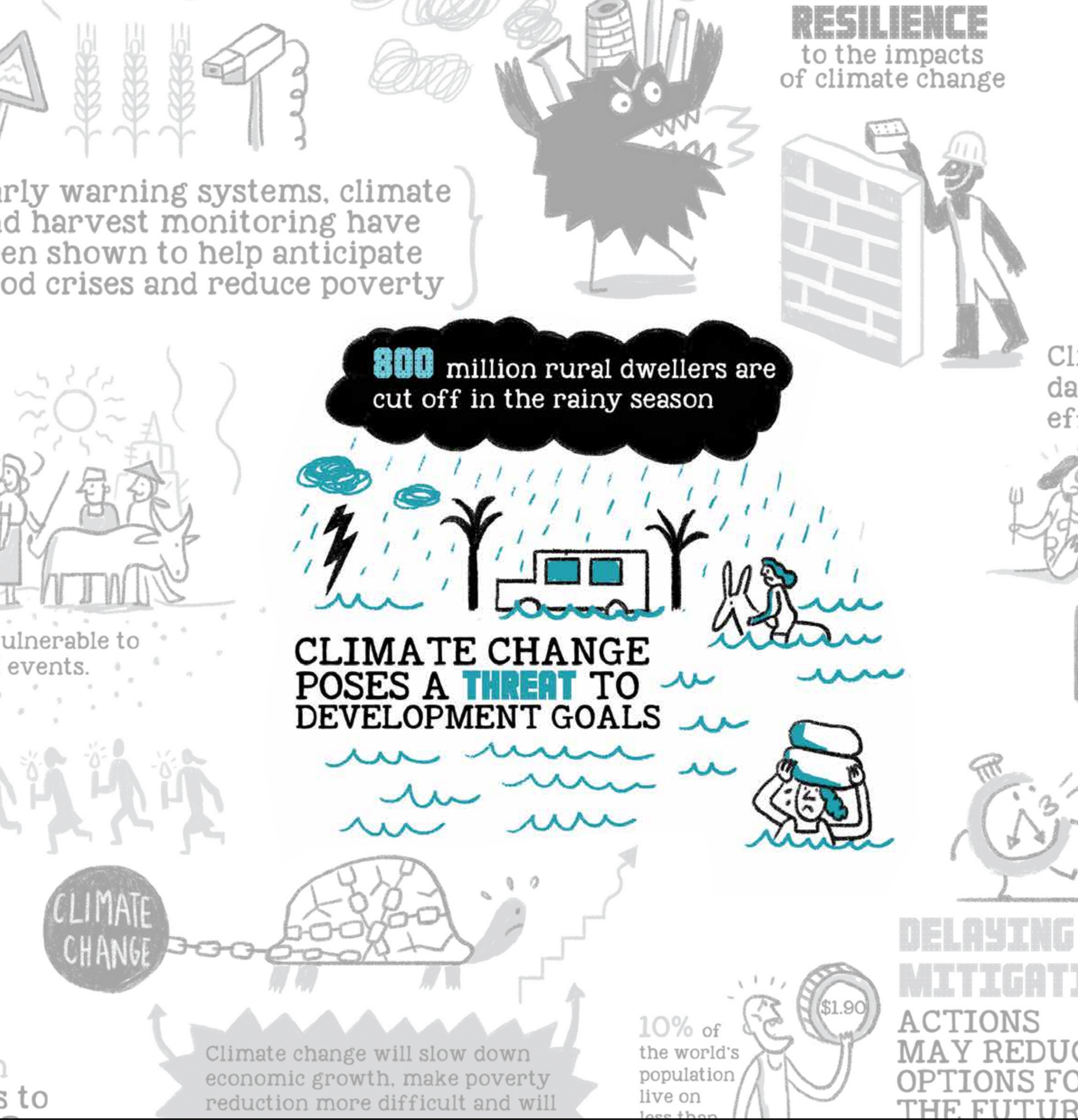
In 2015, we decided to explore these relationships in more detail, this time focusing only on climate extremes in the belief that these manifestations of climate change would most affect our attempts to reduce poverty over the next 15 to 25 years. Climate models are limited in their ability to produce projections of drought, floods and tropical storms, and even what is meant by an extreme will vary between contexts. Yet there is now increasing evidence that climate variability is increasing in many places, with extremes becoming more frequent and intense in some parts of the world. The impact these events have had on poverty levels and poor people varies from place to place but there are some common determinants and lessons for building resilience that apply across a range of extremes and contexts. This report explores this climate change-disaster-poverty nexus through three detailed studies where a clear relationship between climate change, climate extremes, disasters and poverty impacts can be traced.

Chapter 1 presents the challenge of eliminating extreme poverty by 2030 and highlights some of the key mechanisms through which climate extremes lead to disasters, as well as evidence on the links between climate change and development and poverty. Chapter 2 focuses on three types of events where there is clearest evidence of changes in terms of the magnitude, frequency and variability of climate phenomena: climate variability and extremes in the Sahel, storm surges in the Philippines and heatwaves in India. We demonstrate how what was once considered extreme has, in some parts of the world, become increasingly common. In chapters 3–5, we examine patterns of extreme events, exposure and vulnerability in each of the case studies from those three regions and analyse some of the poverty impacts of recent events. We review existing policies to manage climate change risks and assess the adequacy of these, given projections of climate extremes. Through the case studies, we see that disasters clearly have a disproportional impact on the poor because of their exposure and vulnerability to different types of climate extremes. However, the story is more complex at the local level and impacts are not just felt in the places where these extremes occur. The report suggests that the idea of poverty and climate extreme hotspots may be erroneous and more attention needs to be paid to understanding how different groups are vulnerable in order to build resilience capacities.

Chapter 6 discusses principles, planning and policy tools for building resilience in the face of uncertainty. The chapter discusses how solutions will need to link different institutions, prioritise new criteria in decision-making and be flexible in light of different possible climate futures.

Chapter 7 outlines tools and lessons that planners and policy makers need to incorporate in order to accommodate climate extremes in order to achieve resilient poverty reduction. It does so through a set of principles for building resilience. Building on case study findings, it concludes that tackling the combined challenges of poverty eradication and climate risk will require joint action aimed at promoting development, reducing vulnerability to climate extremes and managing exposure to those risks.

This report calls for resilient poverty reduction. To achieve this, the absorptive, anticipatory and adaptive capacities of communities and societies will need to be strengthened. New ways of working to link institutions that have previously been poorly connected are required, with new criteria for decision-making, such as considering the best solutions across different possible climate futures, a priority.



CHAPTER 1

The geography of poverty and climate extremes

Summary

This chapter presents the challenge of reducing extreme poverty under climate change. It argues that climate extremes are the manifestations of climate change most likely to affect poverty over the next 25 years, with impacts on lives, livelihoods and assets impeding efforts to eradicate it.

- While global poverty levels have lessened over the past two decades, progress is uneven both between and within countries.
- Greater seasonal variability and changes in the prevalence and intensity of climate extremes pose serious challenges for poverty reduction in the future.
- Countries with high levels of poverty are also among the most affected by disasters. This is because the determinants of disaster risk are similar to those of poverty, but also because disasters affect the poor disproportionately and in multiple ways.
- At the local level, the picture is more complex and modelling future impacts is particularly challenging, given the uncertainties inherent in projections of extreme events and of poverty.
- Mapping these extremes against poverty indicators is problematic because an 'extreme' event can only be understood relative to local experiences of weather. Greater attention needs to be paid to local sensitivities to extremes.

1.1 Climate change and poverty: an introduction

The complete elimination of extreme poverty by 2030 is one of the internationally agreed Sustainable Development Goals (SDGs). Progress in human development has been remarkable in the last two decades, with global levels of extreme poverty coming down from 43% to 14% (UN, 2015b). However, under the new World Bank definition of extreme poverty, which lifts the poverty line to $1.90 per day (based on the US dollar exchange rate of 2011 instead of the previous 2005 rate), it is estimated that 10% of the world's population live under this threshold (World Bank, 2015d). This progress has not been evenly distributed among or within countries. Around the world, 850 million people still live on less than $1.25 per day, and the number of people living below this poverty line in sub-Saharan Africa increased by 209 million between 1981 and 2010 (World Bank and PREM, 2013). Some 1.3 billion people lack access to electricity, 900 million to clean water and 2.6 billion to improved sanitation; around 800 million rural dwellers are cut off from the world in the rainy season without access to an all-weather road (Fay et al., 2010; IEA, 2011).

Climate change presents both threats and opportunities for future development ambitions. Small dikes used for water management can be used to divert flooding away from settlements and assets, while extremes of precipitation can be harnessed and diverted away for irrigation, and water storage can be used as a buffer against drought. These projects offer opportunities for turning climate variability and even extreme events into benefits. They could be expanded and scaled-up, but tend to be underdeveloped in poor areas. While projections of climate change are often focused on the longer term, when issues such as sea-level rise may threaten the viability of low-lying islands and coastal areas, climate change could also have significant impacts on efforts to reduce poverty in the medium term. Increases in average global temperatures are already generating greater seasonal variability and affecting the timing, frequency and intensity of climate extremes in some areas; these trends are projected to accelerate (IPCC, 2012).

Limiting the scale and extent of impacts is vital. Developing low-carbon approaches to development across the world that could limit global temperature rise to less than 2°C is a pivotal goal. Outcomes of the 21st session of the Conference of Parties to the UN Framework Convention on Climate Change (COP21) in 2015 are central in guiding the efforts of governments, the private sector and civil society to avoid crossing this threshold of 'dangerous' climate change. If the 2°C increase is exceeded, adaptation could become an increasingly costly and potentially implausible mechanism for averting the impact of climate change on poverty eradication. Even on a pathway to a 2°C increase, adaptation is expected to cost $35 billion by

2050 in Africa alone. Globally, catastrophic impacts such as major sea-level rise could begin to result in much larger costs of up to $350 billion a year (Schaeffer et al., 2013).

Whatever the scale of success is in limiting future climate change, some change is already projected as the climate responds to historic emissions of greenhouse gases (GHGs). The task of reaching and sustaining zero extreme poverty in the next 15 to 25 years will be shaped to a large degree by our collective efforts to build resilience to increases in global average temperatures, ocean impacts, climate variability and climate extremes (IPCC, 2014b). Maintaining poverty gains beyond 2030 will also require limiting the increase in mean global temperature to 2°C, necessitating major reductions in GHG emissions toward zero net GHG emissions by the end of the century (Granoff et al., 2015). Achieving this, along with broader decisions about development pathways at local, national and international levels, will determine the direction of change of climate risk globally (IPCC, 2014b).

1.2 The climate change-disaster-poverty nexus

1.2.1 Clarifying the link between poverty, climate change and disasters

The income poor are those whose expenditure (or income) falls below a poverty line. Calculating numbers below that line is useful for describing the poverty profile of a country but it is also important to understand why some people are poor, in order to be able to address the root causes of poverty. Among the key causes are (Haughton and Khandker, 2009):

- Region-level characteristics, which include vulnerability to flooding or typhoons, remoteness, quality of governance, and property rights and their enforcement
- Community-level characteristics, which include the availability of infrastructure (roads, water, electricity) and services (health, education), proximity to markets and social relationships
- Household and individual characteristics, among the most important of which are
  - Demographic, such as household size, age structure, dependency ratio and gender of head
  - Economic, such as employment status, hours worked and property owned
  - Social, such as health and nutritional status, education and shelter.

According to the classification presented above, vulnerability to climate extremes is a regional determinant of poverty. Yet climate extremes can also alter community, household and individual determinants of poverty by, for example, damaging infrastructure, disrupting services and affecting employment, health, education and housing. The IPCC Fifth Assessment Report predicts (with 'medium confidence') that climate change will slow down economic growth, make poverty reduction more difficult and further erode food security, along with also prolonging existing poverty traps and creating new ones, particularly in urban areas and emerging hotspots of hunger (IPCC, 2014a). The IPCCC does not, however, provide a full analysis of the ways in which climate change will affect poverty levels, and we do not attempt to cover that ground in this report either. Rather, we present some of the key mechanisms through which climate extremes lead to disasters and the types of impacts that disasters have on income poverty.

Climate extremes are not synonymous with disaster. Disaster risk is a function of hazard, exposure and vulnerability, with the impact of all hazards on people, livelihoods and assets greater when levels of exposure and vulnerability are high. Disaster risk is the probability of the occurrence of a disaster event, derived from the interaction of physical hazards and the vulnerabilities of exposed elements. (Cardona et al., 2012). The UNISDR defines vulnerability as 'the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard' and exposure as the 'people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses' (UNISDR, 2009).

Although it is difficult to disentangle the relative importance of each of these contributing factors, we know that disaster losses have been rising rapidly and that more disasters are linked to extreme climate events (as opposed to geophysical hazards) now than in the past. Global economic losses from 'natural' disasters today are between $250 and $300 billion each year (UNISDR, 2015), up from $50 billion in the 1980s (UNISDR, 2015), of which a high proportion is due to extreme climate events (Aon Benfield, 2014). Levels of exposure to these extreme events are also rising, driven by global development trends such as:

- population growth
- urbanisation (where new arrivals are forced to live in marginal, hazard-prone places)
- people increasingly living in coastal areas and

Table 1. Examples of disaster impacts that pose challenges to poverty reduction*

	Direct impacts on the poor	Indirect impacts on the poor (via development impacts)
Shorter-term impacts	• Loss of earnings • Loss of assets: housing, savings, crops, land and possessions • Forced consumption of limited assets and savings • Reduced access to food, water and health care • Halt in schooling and healthcare programmes (e.g. vaccinations)	• Loss of economically active persons (through death, injury and sickness) • Loss of labour force and lower productive output (e.g. crops, industry) • Loss of assets: government buildings e.g. healthcare facilities, schools; infrastructure e.g. water, electricity and road networks • Diversion of government and private spending to response • Short term supply chain disruption
Longer-term impacts	• Loss of productive agricultural land • Increase in the price of staple foods • Reduction in food security, leading to malnourishment and stunting • Lowered educational attainment and life expectancy • Undermined future resilience and capacity to cope with shocks • Secondary and longer-term impacts	• Increased spending on imports to meet food demands • Allocation of budgets to reconstruction and recovery • Increased debt responding to recovery needs • Long-term supply chain disruption • Relocation of productive sectors (regionally or internationally) • Reduced income and consumption levels • Reduction in exports and export income and increase in imports • Slower economic growth due to long term consequences of reduced investment in physical and human capital

*This is not an exhaustive list. The impacts are not necessarily independent of each other and can lead to cascading effects or be prevented or circumvented altogether.

floodplains
- the degradation or loss of natural ecosystems (which serve as barriers to flooding)

(IPCC, 2012; UNISDR, 2015).

At the national or regional level, the determinants of disaster risk are similar to the determinants of poverty outlined above. The quality of governance systems, for example, explains to some extent why, since 1990, almost 90% of mortality in internationally recorded disasters has occurred in low and middle-income countries (UNISDR, 2015, p44–45). Faced with the same numbers of people exposed and hazards of the same severity, lower-income countries with weaker governance systems will have significantly higher mortality rates. For a similar level of exposure – to a Category 3 cyclone, for example – around 50% of the variance in mortality risk is explained by vulnerability (UNISDR, 2015).

At the community, household and individual levels, the relationship between disaster risk and poverty is more complex. On the one hand, the determinants of poverty and exposure and vulnerability to climate extremes appear to be quite similar. The poorest people often live on marginal urban land at risk from floods and landslides, and in drought-prone rural areas, meaning they are commonly the most exposed to climate extremes. The poorest also tend to be more vulnerable to these extremes, lacking access to the information and support services needed to prepare for and respond to disasters, or the ability to protect their assets or take out insurance to spread risk. Yet the relationship between poverty and disasters is complicated by the effect that disasters themselves have on the poor. The effects that the death of family members has on the rest of the household are significant and include loss of earnings. However, disasters also affect the incomes, assets and savings of survivors, which can lead to long-term setbacks in health, education and employment opportunities through disadvantages such as malnourishment and missed schooling. Evidence from a number of studies at different scales suggests disasters can cause impoverishment and contribute to poverty traps, as poor people are forced to sell or consume the few assets they have, deepening their poverty and undermining their human capital (see table 1) (Shepherd et al., 2013). This, in turn, undermines people's capacity to anticipate and absorb the impacts of subsequent extreme events or adapt to deal with future shocks (Bahadur et al., 2015), creating a cycle of vulnerability.

1.3 Evidence on the nexus

1.3.1 Nature of the evidence

Empirical studies on the climate change-disasters-poverty nexus look at climate change and its manifestations, along with the development and poverty outcomes at different levels:

- macro (national Gross domestic Product (GDP) and between countries)
- meso (subnational administrative units and cross border regions such as river catchments)
- micro (household and community).

Most studies indicate the direction of the relationships between these phenomena, but often stop short of predicting or measuring the impact of climate change on poverty. They tend to offer evidence at the macro and micro levels, but research at the level of decentralised governance units, river basins and other sub-national administrative or spatial scales is less common: meso-level data is collected less frequently and tends not to be aggregated. Nonetheless, it is precisely at the water catchment and administrative scales – from transboundary rivers/lakes/aquifer systems to micro-basins – that resilient poverty reduction efforts are arguably most needed (McCarthy, 2001). At the macro level, research has tended to focus on GDP growth, which is only part of the story. The multiple dimensions of poverty have been explored more at the micro than macro scale and few studies adopt a holistic approach in which climatic and non-climatic drivers are analysed simultaneously.

Overall, studies on the nexus can broadly be divided into two categories:

- Those examining how climate extremes and disasters have had an impact on poverty and economic growth in the past, usually focusing on one particular event.
- Those using models incorporating climate change projections to create plausible scenarios for how climate change will have an impact on poverty and growth in the future.

For the second category, the precise impact climate change will have on poverty has been particularly difficult to estimate. Climate change projections have their own uncertainties, as do poverty projections (with their many dimensions). Also, not all models agree and, as a result, there are too many uncertainties for reliable results to be produced. Studies give an indication of the direction of some of the effects, but stop short of predicting or quantifying impacts. Statistical relationships have been derived from studies linking climate change projections to development indicators, such as a decline in economic productivity or a rise in the poverty headcount. However, these need to be interpreted with caution, with due attention to both context and high levels of statistical uncertainty. Average annual rainfall or temperature rises can mask the importance of extremes and the significance of specific months or seasons in a particular region and not all changes in climate will be spatially or temporally uniform. Regional and local contexts are important. For example, a 1°C change in temperatures in one region will not have the same effects on livelihoods as the same change in another place; similarly, the precise conditions under which crops are grown differ by region, as do productivity and prices.

1.3.2 Key findings

Most evidence supports the conclusion that disasters lead to negative economic outcomes, particularly in developing countries (Hochrainer, 2009; Noy, 2009). The severity of the disaster plays an important role in determining its economic impact, although developing countries are more sensitive to disasters, regardless of severity. Overall economic losses may be higher in rich countries but even small losses in income at macro and micro levels in low-income countries can have a severe effect on economic growth and the wellbeing of the poorest people respectively. Skidmore and Toya (2002) find a positive correlation between GDP growth and frequency of disaster events, when including expenditure on recovery and reconstruction. This suggests disasters may have a 'creative destruction' effect, in which post-disaster investments in infrastructure and human capital reinvigorate productivity (Skoufias et al., 2011). Overall, the literature on this topic focuses mostly on economic growth impacts, rather than distributional impacts on poor people. However, we know that the impact of disasters is stacked against the poorest, children and other vulnerable groups (Twigg, 2015). At all scales, the socio-economic impacts will be different depending on the level of poverty; the impact on poor people appears to be greater than for the rest of the population.

Models of climate change scenarios provide some evidence of poverty impacts at the sub-national level, demonstrating that a climate-related decline in agricultural yields will have very different impacts across different geographies and groups in society. Studies find that climate change will bring different results in different countries: higher inequality in some, increases in poverty in others and even a decrease in poverty and inequality in others still (Anderson and Verner, 2010). Factors such as household income, the price of staple foods and cost of living at the poverty line are all expected to have more important consequences

Table 2. Climate phenomena and development: A complex relationship across scales

Climate extremes, disasters and development

Authors (date)	Poverty variables	Timescale	Disasters variable	Key findings
				MACRO LEVEL
Noy (2009)	GDP growth	Medium term	Natural disasters (all)	Ability to mobilise resources for the reconstruction and financial condition of a country are important predictors of GDP growth effects.
Skidmore and Toya (2002)	GDP growth, total factor productivity	Long term	Storms, droughts, earthquakes, floods	Positive correlation between frequency of natural disasters and long-term economic growth.
Loayza et al. (2012)	GDP growth	Medium term	Droughts, floods, storms, earthquakes	Disasters affect economic growth, but not always negatively. Moderate disasters can have a positive growth effect, but severe disasters do not. Economic growth in developing countries is more sensitive to disasters.
Raddatz (2009)	GDP growth, output volatility	Short term	Rainfall shocks, storms, earthquakes.	Climate disasters have a negative economic effect, with 1% loss in GDP after droughts.
Hochrainer (2009)	GDP growth, indebtedness	Short term, medium term	Earthquakes, volcanic eruptions, cyclones, rainfall shocks	Natural disasters on average lead to negative effects on GDP, with the scale of losses dependent on loss of capital stock.
				MESO LEVEL
Rodriguez-Orregia et al. (2012)*	Food-based poverty, capability-based poverty, asset-based poverty	Short term, medium term	Floods, frost, droughts, storms, other events	Occurrence of natural disasters reduced the Human Development Index by about 1% per municipality, with droughts and floods causing the most severe impact.
				MICRO LEVEL
Dercon et al. (2005)	Consumption	Short term, long term	Drought	Rainfall shocks have substantial impacts on consumption growth, which persists for years.
Skoufias and Vinha (2012)	Child height	Short term	Rainfall shocks	Extreme temperatures and flooding can negatively impact agricultural productivity, increasing possibilities of malnutrition in young children. The study finds that Mexican children are shorter on average after a year of high precipitation and are similarly shorter two years after extreme temperature lows. These impacts could be from reduction in household consumption or from increasing prevalence of diseases associated with weather shocks.
Hoddinott and Kinsey (2002)	Child height	Short term	Drought	Children aged 12–24 months lose up to 2cm of growth after a drought. There is no evidence that older children experience a slowdown in their growth.
Carter et al. (2007)	Productive assets, income	Medium term, long-term	Drought, hurricane	After Hurricane Mitch, wealthy households were able to at least partially rebuild lost assets. The lowest wealth group felt effects of shock more acutely and for longer. After a drought in Ethiopia, the lowest wealth groups refrained from selling assets important to their livelihoods during periods of severe agricultural productive loss. This led to a drop in household consumption.

Poverty dimensions

- Education
- Health and malnutrition or mortality
- Economic income and growth
- Inequalities
- Agricultural output or productivity
- Household consumption
- Human Development Index composite

*These studies apply to more than one dimension of poverty.

Climate change and development

Authors (date)	Poverty variables	Past/future	Disasters variable	Key findings
				MACRO LEVEL
Nordhaus and Boyer (2000)	Output per capita	Future	Temperature change scenarios	Climate change scenario with warming but no precipitation change shows -0.9% on output.
Hertel and Rosch (2010)	Production, trade, income, staple food prices	Future	Temperature change, high/ low productivity scenarios	There is a 32% cereal price increase in pessimistic scenario and 16% increase in optimistic scenario. Yield changes are poor predictors of change in national poverty levels because changes in earnings are more important drivers of household poverty than commodity prices.
Cline (2008)	Agricultural output	Future	Business-as-usual warming scenario	Climate change will have modest negative impacts on agricultural yield in the global aggregate, with losses concentrated more heavily in developing countries.
				MESO LEVEL
Skoufias and Vinha (2013)	Consumption	Past	Climate variability (rainfall or temperature)	A household's ability to protect its consumption from weather shocks depends on the nature of the shock, when in the agricultural year the shock occurs and the climatic region. Ability to smooth consumption depends on proximity and access to transportation.
Anderson (2006)	Output, GDP, income	Future	Climate scenarios of 3.9°C mean increase	By 2100, based on a scenario of 3.9°C warming, climate change may cause an additional 12 million people to be in poverty in South Asia and 24 million to be in poverty in sub-Saharan Africa.
				MICRO LEVEL
Assuncao and Chein Feres (2009)	Agricultural output	Future	Temperature and rainfall scenarios	Based on IPCC projections, climate change will increase the poverty rate in rural areas of Brazil by 3.2% by 2050.
Jacoby et al., (2011)	Agricultural output, cereal and land prices, wages	Future	Subnational temperature change scenarios, divided by political districts	National poverty rate in India will rise by 2–4% compared to zero warming scenario. Fall in agricultural productivity (17% overall) will translate into modest consumption decline, as households derive the bulk of their income from wage employment. Rural wages are estimated to fall by only a third of agricultural productivity.
Anderson and Verner (2010)*	Inequality, education, consumption, income	Future	2°C increase in temperature	Municipal data shows that climate change will have heterogeneous effects, with a decrease in poverty in Bolivia and increases in poverty in Brazil, Chile and Peru. Inequality is expected to remain neutral for Peru, Mexico, and Chile, increase in Brazil, and decrease in Bolivia.
Dell et al., (2009)	GDP	Future	1°C temperature increase	There is a negative relationship between temperature increase and GDP, a relationship that exists both within and across countries. Half of negative short-run effects of climate change on GDP are offset in the long run due to adaptation.

Poverty dimensions

- Education
- Health and malnutrition or mortality
- Economic income and growth
- Inequalities
- Agricultural output or productivity
- Household consumption
- Human Development Index composite

*These studies apply to more than one dimension of poverty.

for poor households than yield changes (Skoufias et al., 2011; Hertel and Rosch, 2010). Projected economic and demographic growth plays an important part in the diversity of responses to temperature changes in different countries, yet population growth projections are not often incorporated into climate models. As such, these models are most usefully interpreted as an indication of the direction of the diverse effects of climate change on poverty, rather than as a forecast of what will happen (Skoufias et al., 2011). Furthermore, most studies also do not take adaptation to climate change into account as a factor that mediates impact, although one study found that up to half of the short-term negative impacts of climate change could be offset through adaptation (Hertel and Rosch, 2010).

The table above presents a summary of evidence on climate change-development/poverty links at the micro, meso and macro levels, demonstrating a diversity of relationships and impacts (Skoufias et al., 2011; Dercon et al., 2005; Noy, 2009; Hertel et al., 2010; Jacoby et al., 2011). It is not an extensive literature review but the sample of studies considered is recognised as having important findings on this topic.

1.4 The geographical location(s) of poverty and climate extremes

1.4.1 A co-location of climate change and poverty?

As described above, the impact of climate extremes on poverty is mediated by levels of vulnerability and exposure. Climate change and poverty each have a distinct geography, with high levels of heat, rainfall and droughts more prevalent in specific regions (UNISDR, 2009; IPCC, 2012) and poverty also concentrated in particular parts of the world. Nonetheless, the maps below show some co-location in terms of regions where poverty levels are high and where the largest relative changes in temperature and rainfall are expected.

Figure 1 (below) shows poverty indicators for the period 2010–2012, comparing the share of the population living on less than $1.25 per day (the poverty indicator used in the SDGs) across developing countries. It will come as no surprise that the countries with the highest proportion of extreme poverty are located in sub-Saharan Africa, South and Southeast Asia. Some places with the highest levels of poverty will also see large annual temperature increases and changes in precipitation by the end of the century. Figure 2 shows a global temperature increase of several degrees above the present day, but it can be seen that far larger temperature increases are projected over much of the land, particularly the Arctic and continents

Figure 1. Share of the population living on less than $1.25 per day

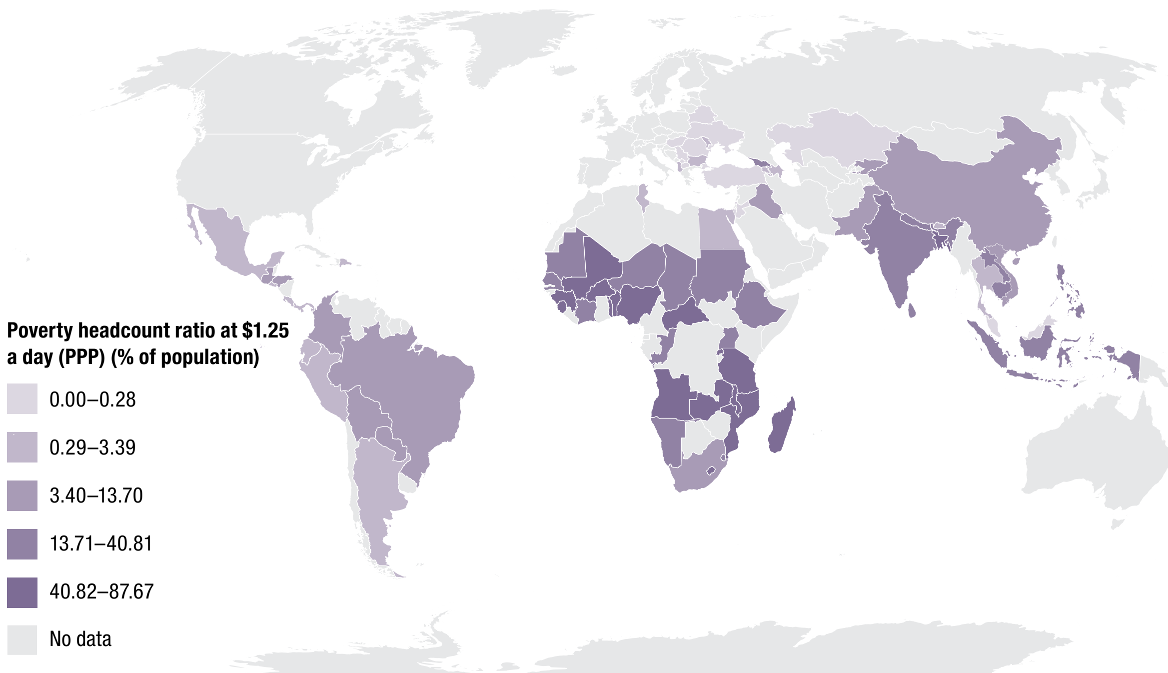
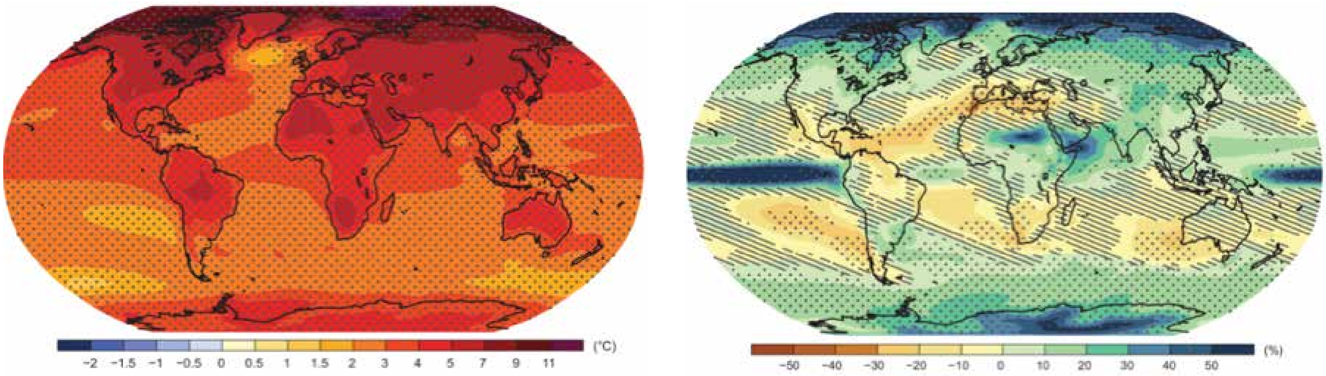


Figure 2. Annual surface temperature and precipitation change

Change in average surface temperature (1986–2005 to 2081–2100) **Change in average precipitation (1986–2005 to 2081–2100)**



These are maps of annual surface temperature change (darkening to red) and precipitation (darkening to blue) changes by the end of the 21st century under a business as usual GHG scenario. Hatching indicates regions where the projected change is relatively small. Stippling indicates regions of relatively large changes with high climate model agreement. See IPCC AR5(18) for full description.

in high latitudes. These long-term trends show significantly warmer average temperatures and large regions of decreasing annual rainfall (e.g. North Africa and the Mediterranean, and South Africa) and increasing annual rainfall (e.g. South Asia and East Asia). Many of these regions also have high concentrations of poverty.

However, an important characteristic often missed when discussing global changes is that low-latitude tropical regions – due to their relatively stable year-round climates – are projected to see some of the largest relative changes. This has led them to be identified as climate change 'hot spots' (Diffenbaugh and Giorgi, 2012). In addition, in some regions with large year-to-year rainfall variability, such as the Sahel,

Box 1. Difficulties with climate and poverty hotspot mapping at the sub-national level

In this report, we began by mapping 'hot spots' of poverty and overlaying these nodes with climate information to identify areas vulnerable to climate-related shocks. 'Hot spots' in Africa were selected according to areas with high incidences of malnutrition (using child height-for-age Z score as a proxy for long-term nutritional status). This approach did not work well: there are a multitude of reasons why people are poor and a paucity of direct causal evidence regarding how climate-related shocks and stresses impact longer-term wellbeing outcomes. Poor households deal with idiosyncratic stresses, such as health problems or unemployment, in addition to larger structural barriers, including poor access to services. Worsening climate extremes are one piece of a larger puzzle.

An initial 'hot spot' analysis focused on Kenya, where areas of high malnutrition did not match areas of drought severity and length. Instead, they corresponded to areas of population density. Much of the concentration of severe malnutrition is around large metropolitan areas, where over 40% of children living in slums are stunted. Also, although Kenya's arid lands have high rates of poverty and malnutrition, the absolute numbers of those living in deprivation are significantly larger in Kenya's western and central areas. This makes the 'hotspots' approach of limited use to explain the socioeconomic impacts of drought in the north. Ultimately, there is rarely a direct geographical relationship between drought and concentrations of high malnutrition because economic and political factors that play an important role cannot be wholly captured through a mapping exercise.

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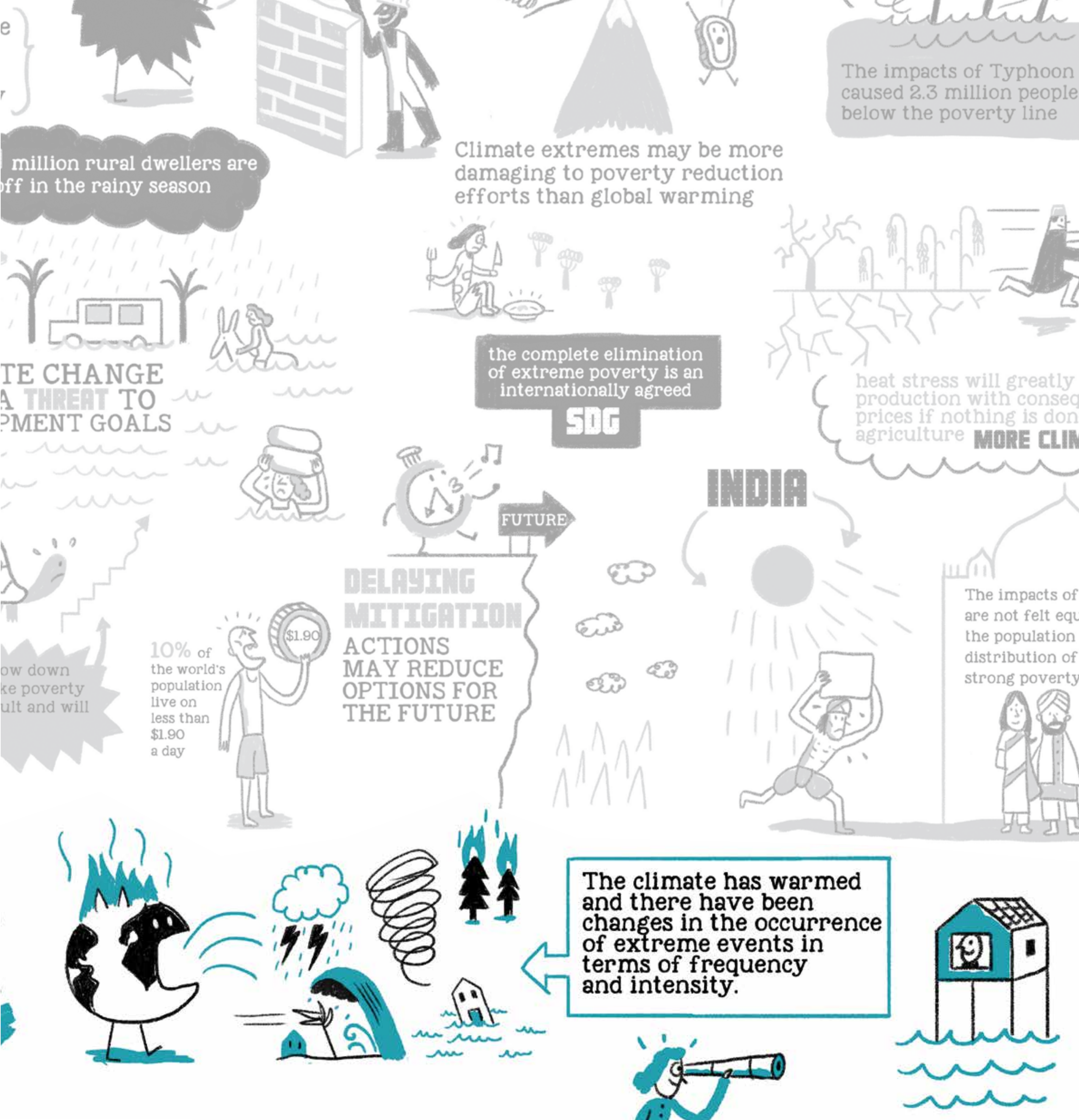
climate model agreement on the scale and sign of rainfall change is low. However, due to their already sensitive nature, any change in the timing, intensity or frequency of rainfall is likely to have relatively large impacts in these areas. It is partly for these reasons, that it is important to consider local climatic conditions when assessing how the poorest parts of the world will be affected by climate change.

1.4.2 A co-location of climate extremes and poverty?

The maps in Figures 1 and 2 indicate an overlap between countries with high levels of poverty today and those that face large annual temperature increases and changes in precipitation by the end of the century. However, it is far less clear that this relationship holds for climate extremes (see box 1), which will potentially have a much larger impact on poor people over the next 15 years.

> **Climate scientists generally define an extreme as an event in the tail of the probability distribution**

Understanding climate extremes is more challenging than interpreting averages for two reasons. Firstly, while climate models are useful tools for understanding long-term climate trends, their ability to forecast changes in extremes is both more limited and less well understood. This makes it much more difficult to draw meaningful conclusions from maps of extremes that are based on climate model projections. Secondly, defining what is meant by an extreme event is problematic, as this can depend very much on the local experience of such weather events. Climate scientists generally define an extreme as an event in the tail of the probability distribution. It does not necessarily follow that such an event – however extreme it is, relative to the climatology – will have a large impact. How relevant an extreme actually is, depends on the local experience of weather and this is difficult to 'map' in a way that is useful for understanding likely impact. The maps of multi-hazard projections that were used in the 2013 Geography of poverty, disasters and climate extremes report, for example, were based on mathematical thresholds of 'extremeness', not how the events were felt locally. This allowed for a comparison between countries but did not provide information on actual drought/flood events for individual countries or sub-national units within them. More information is needed on local sensitivities to climate extremes. We need, for example, to have a clear understanding of the types of droughts that have the largest impact on specific regions and which groups are most vulnerable to them.



CHAPTER 2

Climate extremes on the rise

Summary

Overall, the science for explaining the relationship between global warming and extreme events, and for modelling future changes in those extreme events, has been improving. However, much is still unknown and we are unlikely to ever be able to accurately forecast changes in climate extremes. This chapter explores the latest science on climate extremes and the extent to which recent extreme events are representative of changing risks due to climate change. It explores the climate context for each of the three case studies we present in chapters 3, 4 and 5. We examine climate variability and extremes in the Sahel, storm surges in the Philippines and heatwaves in India. We demonstrate how what was once considered unusual in terms of the magnitude, frequency and variability of climate phenomena has, in some parts of the world, become the 'new normal'.

- Human activities have been identified as a key driver in the changing climate over the last 50 years; the climate has warmed (IPCC, 2014a) and there have been changes in the occurrence of extreme events (IPCC, 2012).
- Additional energy in the form of heat in the climate system may have non-linear and unexpected effects, as the system itself is inherently chaotic.
- While there are some global trends, it is most appropriate to discuss changes at the local scale as extremes occur relative to what is normal in a specific context. Attribution analyses can examine whether local or regional extremes are becoming more frequent due to climate change (Stott et al., 2013; Trenberth et al., 2015).
- In the West African Sahel, large-scale global processes in the atmosphere and oceans affect the climate for the region where, for the last 50 years, "there is no such thing as 'normal' rainfall" (Hulme, 2001:19); recent periods of variability include changes in the timing and intensity of rainfall, with implications for drought and flood events, and downstream impacts on productivity.
- In the Philippines, Super Typhoon Haiyan was an extreme event with widespread consequences; the climate change footprint was evident in the height of the devastating storm surge, which was exacerbated by anthropogenic climate change, having caused sea level rise (Takayabu et al., 2015).
- The number of extreme hot days experienced over much of the world's land area continues to rise. In the case of India, extreme hot temperatures and heatwaves were observed throughout the country in 2015.
- Climate extremes like those illustrated by these three examples are having dramatic impacts on people's lives, and a growing evidence base articulates how climate change is increasing the risk of these events.

2.1 Climate change and extreme events

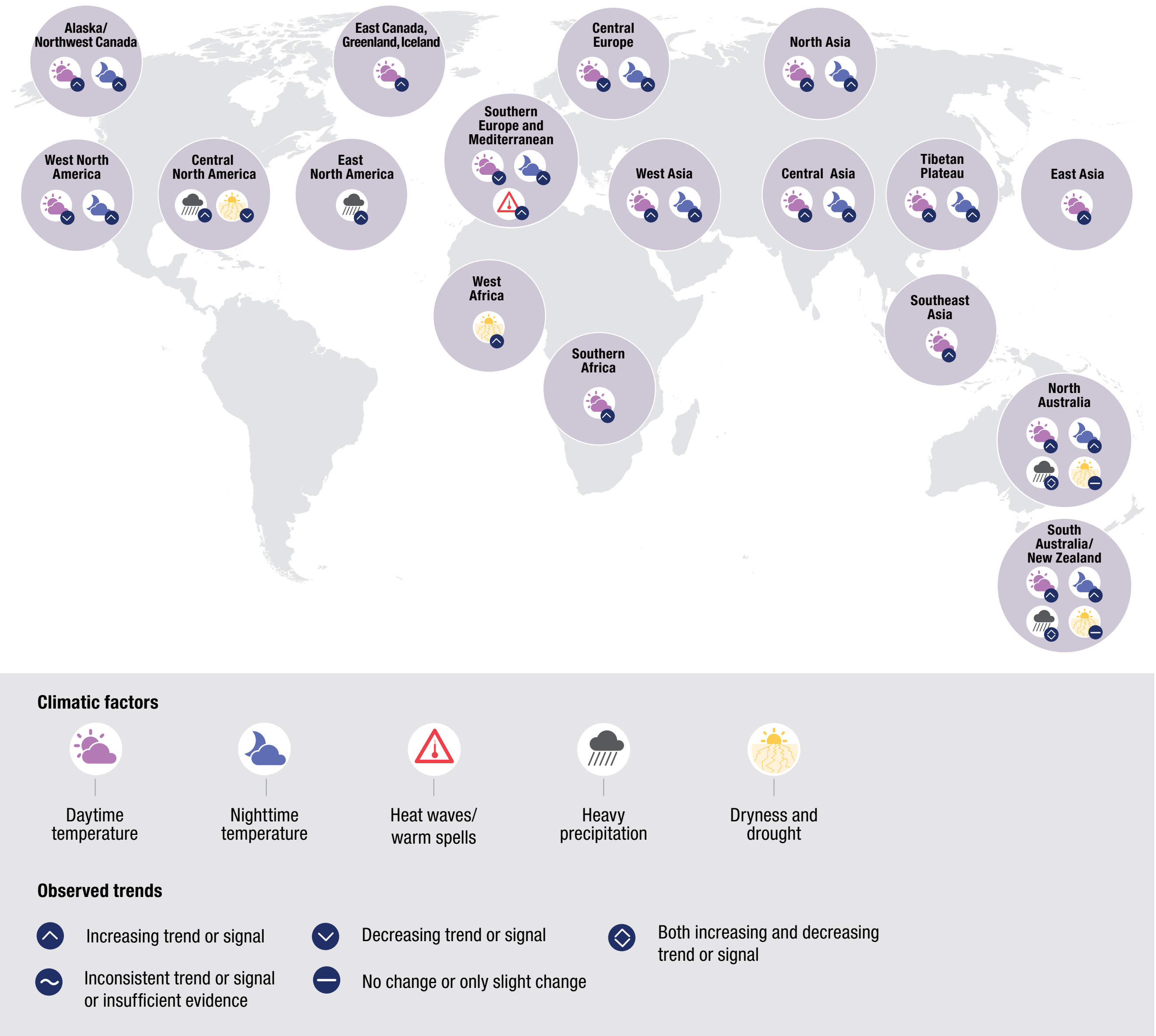
As our climate has warmed in the past 50 years (IPCC, 2014a), we have also seen changes in the occurrence of extreme events (IPCC, 2012). The climate system is inherently chaotic, meaning that additional heat retained within the earth system through anthropogenic climate change may have non-linear and unexpected impacts (James and Washington, 2013). This additional heat can affect all aspects of weather and climate (Lorenz, 1993). We observe these dynamical and thermodynamic responses when weather events change in frequency, intensity, spatial extent, duration and timing (IPCC, 2014a).

While there are some global trends, such as a decrease in the number of cold days and nights and an increase in the number of warm days and nights, extreme events are measured relative to the normal climate in a region, so it is most appropriate to discuss them at a local scale and in the context of local sensitivities. For example, heat-related deaths increase at temperatures over 25°C in England, while in the plains areas of India, a heatwave is considered to be 40°C or higher (NRDC, 2015; Public Health England, 2015). In the UK, average temperatures in the summer range from 12°C to 22°C, and people are acclimatised to this range (Leemans and Cramer, 1991). In contrast, people in the plains areas of India regularly experience average temperatures of about 34°C during May, the warmest month of the year, and 'extremes' occur relative to this very different 'normal' (Leemans and Cramer, 1991).

The human physiological threshold for heat stress depends on both temperature and relative humidity (Sherwood and Huber, 2010). While people do have different heat tolerances depending on where they live, regions that already have high normal temperatures will breach the threshold humans can tolerate more often, as the number of warm days and nights increase. In tropical and subtropical heat-related stress on populations is therefore more common as these places already have high temperatures and humidity. High humidity reduces our ability to regulate body temperature through sweating, making it harder for humans to tolerate extreme heat stress (Kenney et al., 2004).

Climate extremes have always impacted on people's lives, however, we are now beginning to see changes in the frequency and intensity of these extremes and increasing evidence of how climate change is contributing to these events (e.g. Herring et al., 2014). Figure 3 below shows how some extremes have changed in different parts of the world in the past half-century. In this chapter, we focus on several examples of extreme events that have had drastic consequences on today's society, illustrating the climate context for each one. Disasters occur all over the world and know no administrative boundaries. Nevertheless, certain countries have suffered disproportionately. In terms of numbers of people killed, injured and made homeless by natural hazards, the countries selected for this study (Mali, India and the Philippines) are amongst the most affected by disasters (see figure 4).

Figure 3. Observed changes in temperature and precipitation extremes as defined in the IPCC SREX report (high confidence)



2.2 Climate variability and extremes in the Sahel

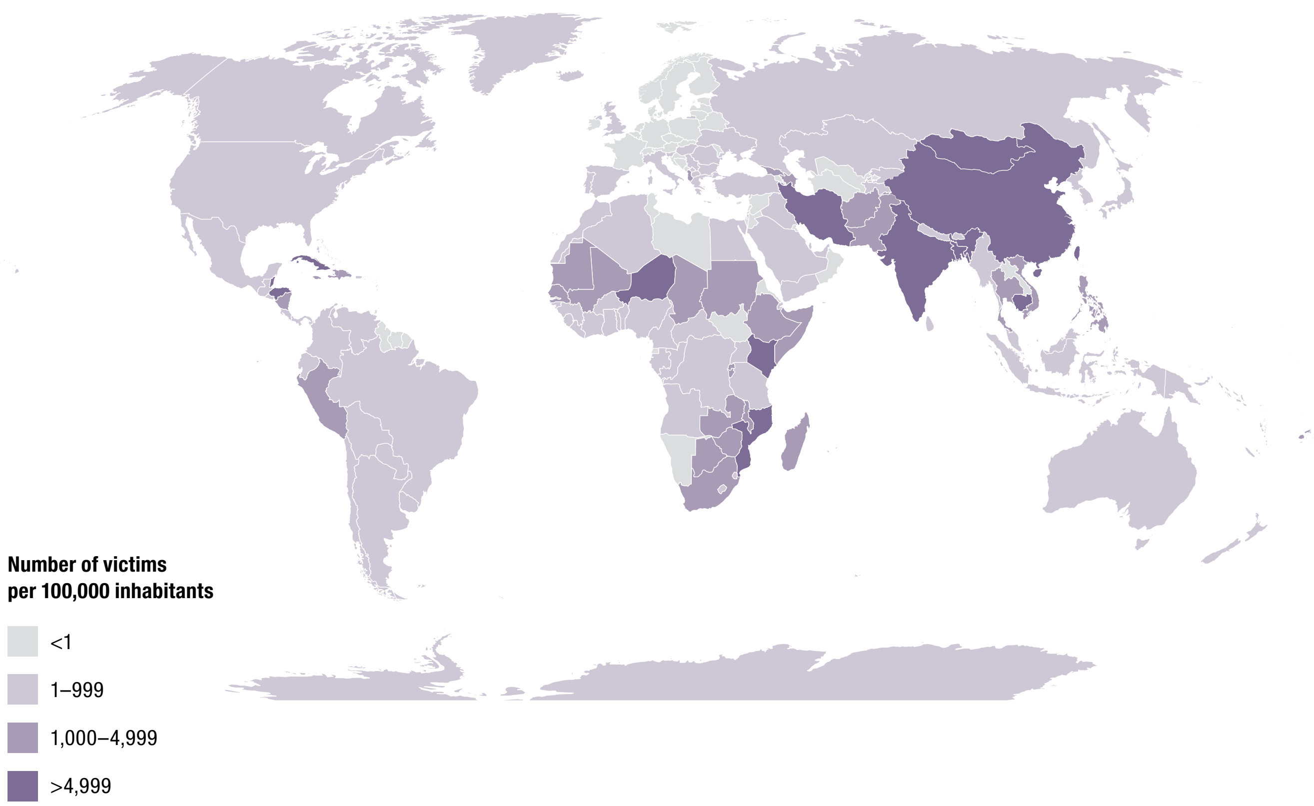
Natural variability occurs on annual, decadal and multi-decadal timescales that result in periods of drier and wetter conditions. Across decades, regional climates vary naturally and are affected by large-scale global processes in the atmosphere and oceans. These process create, for example, periods when there are more extreme wet or dry events, which can be catastrophic to vulnerable groups. In some locations, the rainy season can vary strongly from one year to the next. One region that has experienced high levels of variability and extremes in the past 50 years is the African Sahel (figure 5). In fact, as Hulme (2001: 19) states, "There is no such thing as 'normal' rainfall in the Sahel."

The Sahel is a semiarid region in Africa between the Sahara desert to the north, and the wetter savannah zone to the south. Most livelihoods in the Sahel are based on rain-fed agriculture and animal husbandry, relying on a single rainy season between June and September (Halpert and Bell, 1996). During this season, the West African monsoon moves northward from the Equator, providing people from the region with an opportunity to grow crops and raise livestock that will support their families for the entire year. This strong dependence on consistently adequate rainfall makes the region particularly vulnerable to changes in the climate (Sarr et al., 2015; Kandji et al., 2006).

Oceans located thousands of miles away from the Sahel played a key role in determining the location, strength and extent of the West African monsoon

In the past 50 years the Sahel has changed remarkably. The 1950s and 1960s saw a series of consistently wet rainy seasons, leading to high agricultural productivity, with people expanding cultivation into marginal lands near the Sahara desert (Nicholson et al., 2012). This period of relative prosperity had ended by 1970 and a devastating drought took hold, peaking

Figure 4. Number of reported victims of natural disaster by 100,000 inhabitants, 1996–2005



Source: Guha-Sapir, D., Below, R., and Hoyois. Ph. (n.d.) EM-DAT in 1973–4 and contributing to an estimated 100,000 deaths across sub-Saharan Africa (Kandji et al., 2006). The drought led to hunger, malnutrition, soil deterioration and mass migration towards the urban centres and southern regions of the Sahel. People abandoned the areas they had moved into in the 1950s and instead settled in low-lying coastal areas. Dakar, for example, saw a population boom, as did nearby towns.

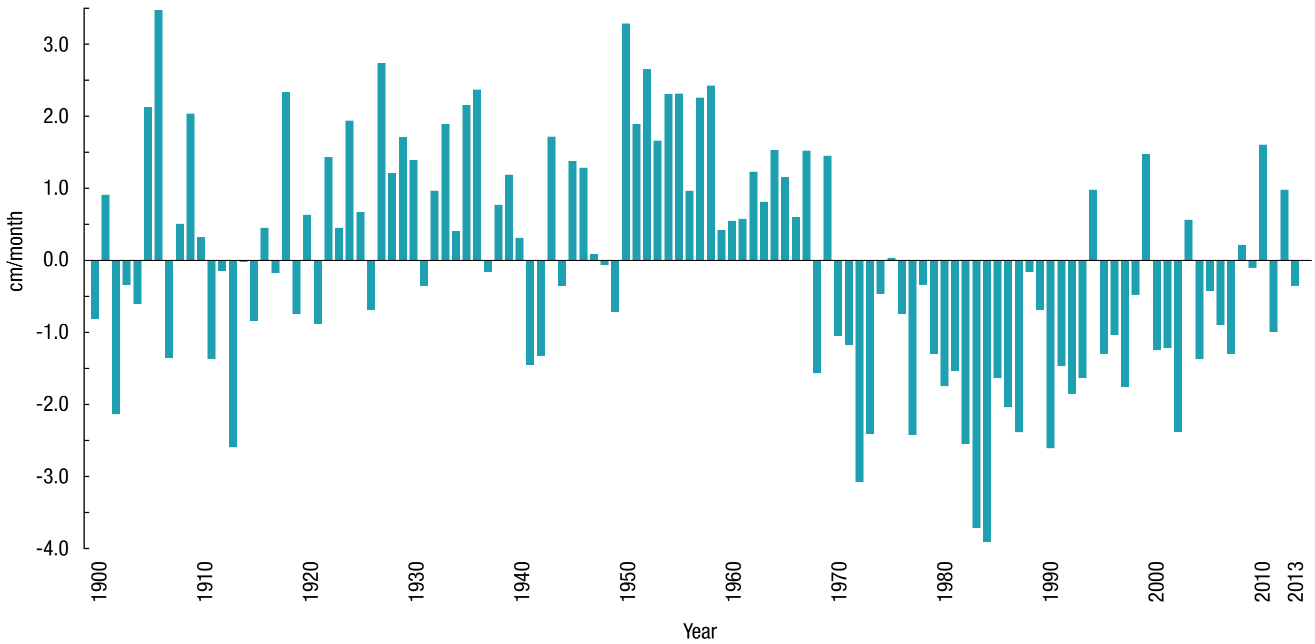
Oceans located thousands of miles away from the Sahel played a key role in determining the location, strength and extent of the West African monsoon. In the 1950s and 1960s, the tropical oceans were unusually cool and the North Atlantic Ocean was unusually warm (Giannini et al. 2013). This pushed the monsoon up towards the Sahel, bringing heavy rainy seasons every year. In the 1970s and 1980s, the temperature anomalies in the oceans reversed, keeping the monsoon closer to the Equator and resulting in much lower rainfall across much of the Sahel (Giannini et al., 2013). Such changes are part of the normal cycles of the oceans, but these particular changes were also affected by anthropogenic smog produced around the world at this time (Rotstayn et al., 2002). Because the atmosphere abides by no national boundaries, changes to our worldwide climate in one place can have drastic impacts in other regions.

Another climatic shift occurred in the mid-1990s, when the Sahel started to recover some of its rainfall and entered a period characterised by increased variability and extremes (Lebel et al., 2009). At the same time, the Earth's atmosphere was warming at an unprecedented rate, due to anthropogenic climate change, with this contributing to large annual fluctuations in rainfall rates.

For example, rainfall in 2009 was close to the long-term average, followed by extremely high rainfall in 2010, then unusually dry conditions in 2011 (Nicholson, 2013). This lack of consistency also shows within each rainy season. While the total seasonal rainfall may be high, the character of precipitation has shifted towards fewer, but more intense, rainfall events (Salack et al., 2014 Ali et al., 2008). The range of rainfall variability in time and space matters most for environmental and social systems that must adapt to these changing climates (Hulme, 2001). Changes in the character of rainfall mean there are sometimes dry spells for days or weeks at a time, followed by downpours that make up a quarter, half or even the total expected seasonal rainfall in one day (Ali et al., 2009). This is different from the wet period in the 1950s, which exhibited more moderate, consistent rainfall over the course of the rainy season (Giannini et al., 2013).

This highly variable and unpredictable 'new normal' for Sahel rainfall has direct impacts on the

Figure 5. Sahel precipitation anomalies 1900–2013



Note: June through October averages over 20–10N, 20W–10E. 1900–2013 climatology NOAA NCDC Global Historical Climatology Network data.
Source: NOAA (2013)

predominantly pastoral livelihoods in the Sahel. Pastoralists' livelihoods are intrinsically linked to seasonal cycles, as the agrarian base of the food economy is affected by the rainy season, depending on availability of pasture and the ability to plant or fish in the river basins and great lakes. With increasingly erratic rainfall that arrives too early or too late, too much or too little, it is difficult for pastoralists to develop a consistent strategy to adapt to the changes in rainfall. If people do not adapt to increasing variability, this can lead to rising vulnerability and reduced absorptive, anticipatory and adaptive capacity (Bahadur et al., 2015). In addition, rainfall is not the only changing factor in this region; changes to temperatures can also affect water availability and livelihoods.

2.2.1 What is the role of climate change?

Rainfall in the Sahel varies due to natural fluctuations in the Earth's climate system. Warming due to anthropogenic climate change shapes the way these fluctuations work, creating a complex labyrinth of causes and effects that has ultimately led to the changing occurrence of extremes.

The two major drivers of regional climate in the Sahel are the tropical oceans and North Atlantic Ocean (Giannini et al., 2003; Zeng, 2003). Climate change has caused the tropical oceans to warm, particularly around the Gulf of Guinea. This makes it more difficult for rain-bearing clouds to form, in turn resulting in less rain. However, the North Atlantic Ocean has also been warmer than normal and this makes extra moisture available to fuel the West African monsoon. Each of these two opposing drivers actively resists the influence of the other, partly explaining why climate variability in the Sahel has increased in recent decades (Giannini et al., 2003). Further research by Dong and Sutton contends that human-caused greenhouse gases and aerosols may be partly responsible for increased variability (2015).

Scientific research has shown that the recent trend of increasing variability is linked to climate change and will continue to remain an important factor influencing the amount, intensity and timing of rains in the Sahel (Giannini, 2010). The future of the Sahel, intricately linked to the changing climate through the temperature of the oceans as well as the land, underscores the need for understanding the region-specific implications of climate science to inform initiatives to build resilience to climate extremes.

2.3 Storm surge: Super Typhoon Haiyan

While variability is always a factor in today's world, very extreme events can have shocking consequences. Around the globe we occasionally experience events that break all prior records, partly because improbable events do happen, but also because climate change is making these abnormal events more likely. One very extreme event was Super Typhoon Haiyan, which tore through the Philippines in 2013, leaving a wake of massive destruction. Haiyan had an impact on millions of people in the Philippines, Micronesia, Vietnam and South China, and there were over six thousand confirmed deaths, mostly due to storm surge (NDRRMC, 2014; Lagmay et al., 2015).

Typhoons, hurricanes and tropical cyclones are all the same type of storm, given different names according to which ocean they occur in. In the Western Pacific Ocean they are given the moniker 'Typhoon', with the Joint Typhoon Warning Center using a Tropical Cyclone Intensity Scale that defines the intensity of a storm by the 1-minute maximum sustained wind speeds. Other regional warning centres use slightly different metrics (World Meteorological Organization, 2012).

A storm must achieve sustained wind speeds of at least 241 km/hr to be classified as a super typhoon (World Meteorological Organization, 2012). According to the Japan Meteorological Agency, Haiyan's peak 1-minute sustained wind speed was 315 km/hr, making it the strongest tropical cyclone ever observed in terms of peak winds (Yi et al., 2015; Blunden and Arndt, 2014). The central pressure, a key measure of cyclonic strength, was very low at 895mb, leading to a raised sea surface because there was less downward pressure exerted on the water. To add to this, Haiyan was vast – 600km from one side to the other – meaning its impact was felt across a huge area (Lagmay et al., 2015).

According to the Philippines authorities, Haiyan was one of the most powerful typhoons to make landfall in recorded history (Mahar et al., 2014). Perhaps Haiyan's most important property, however, was the storm surge – a bulge of water that can plough through homes, roads and bridges, and rapidly causes the water level to rise in coastal communities, leaving little time for residents to escape. Haiyan's storm surge, which at its largest was between five and six metres high, was responsible for many of the lives lost (Lagmay et al., 2015).

2.3.1 What is the role of climate change?

The height of Haiyan's storm surge would not have been as extreme in a world without anthropogenic climate change (Takayabu et al., 2015). Globally, sea levels are rising due to climate change for two primary reasons: firstly, ice is melting from the land and entering the oceans and, secondly, the oceans are expanding as they warm (Nicholls and Cazenave, 2010). There is an observed global trend of increasing sea levels, but precise changes vary according to location. The Philippines in particular is an area of the world where sea level has been regionally increasing faster than the global average. Based on historical records, the increase in sea level near the Philippines in the past 150 years is estimated at between 0.25 and 0.3 metres (Takayabu et al., 2015).

One study modelled Typhoon Haiyan to see how sea level rise might have affected the outcome, comparing it to a hypothetical event in a world without climate change. They estimated that climate change had contributed up to a 20% increase in Haiyan's storm surge near Tacloban, a city that experienced some of the most widespread surge damage (Takayabu et al., 2015). This 20% increase translated into additional casualties and increased economic losses.

While it is clear that climate change increased the strength and impact of Haiyan's storm surges, leading to deadly impacts, there is not yet enough information to conclude whether it also affected other aspects of the storm, such as the intensity of wind and rain. Moreover, societal factors, including the way in which warnings were issued and interpreted, also factored into the high number of casualties from Super Typhoon Haiyan.

Lessons learned about storm surge could be applied elsewhere; there are, for example, a number of megacities worldwide that are vulnerable to sea level rise and tropical cyclones that can cause this type of surge event, including New Orleans in the USA, Shenzhen in China and Nagoya in Japan (Hallegatte et al., 2013).

2.4 Heatwaves in India

Extreme heat is one of the most easily identified impacts of climate change, which is itself also referred to as 'global warming'. As far back as 2004, when scientists analysed the devastating 2003 heatwave in Europe, it was identified that human-induced climate change had at least doubled the risk of such a strong heatwave (Stott et al., 2004). More recently, record temperatures in Australia in 2013 were shown to be five times more likely than in a world without climate change (Lewis and Karoly, 2013). Although there was discussion of a hiatus in the rise of the global average surface temperature in the decade beginning in 2000 (Tollefson, 2014), the number of extreme hot days has been rising steadily in most of the world since 1997 (Seneviratne et al., 2014).

Around the world, heat extremes are on the rise (Smith et al., 2013; Perkins et al., 2012; Alexander et al., 2006) and the effects can be exacerbated locally by urban heat island effects and poor air quality (e.g. Zhang 2013; Wilby, 2008). Global trends in extreme temperatures make it likely that heatwaves will increase almost everywhere; climate model projections suggest extreme heat increases are likely across most of the planet (Sillmann et al., 2013).

The changing climate is also projected to affect the timing, frequency and intensity of rainfall across South Asia

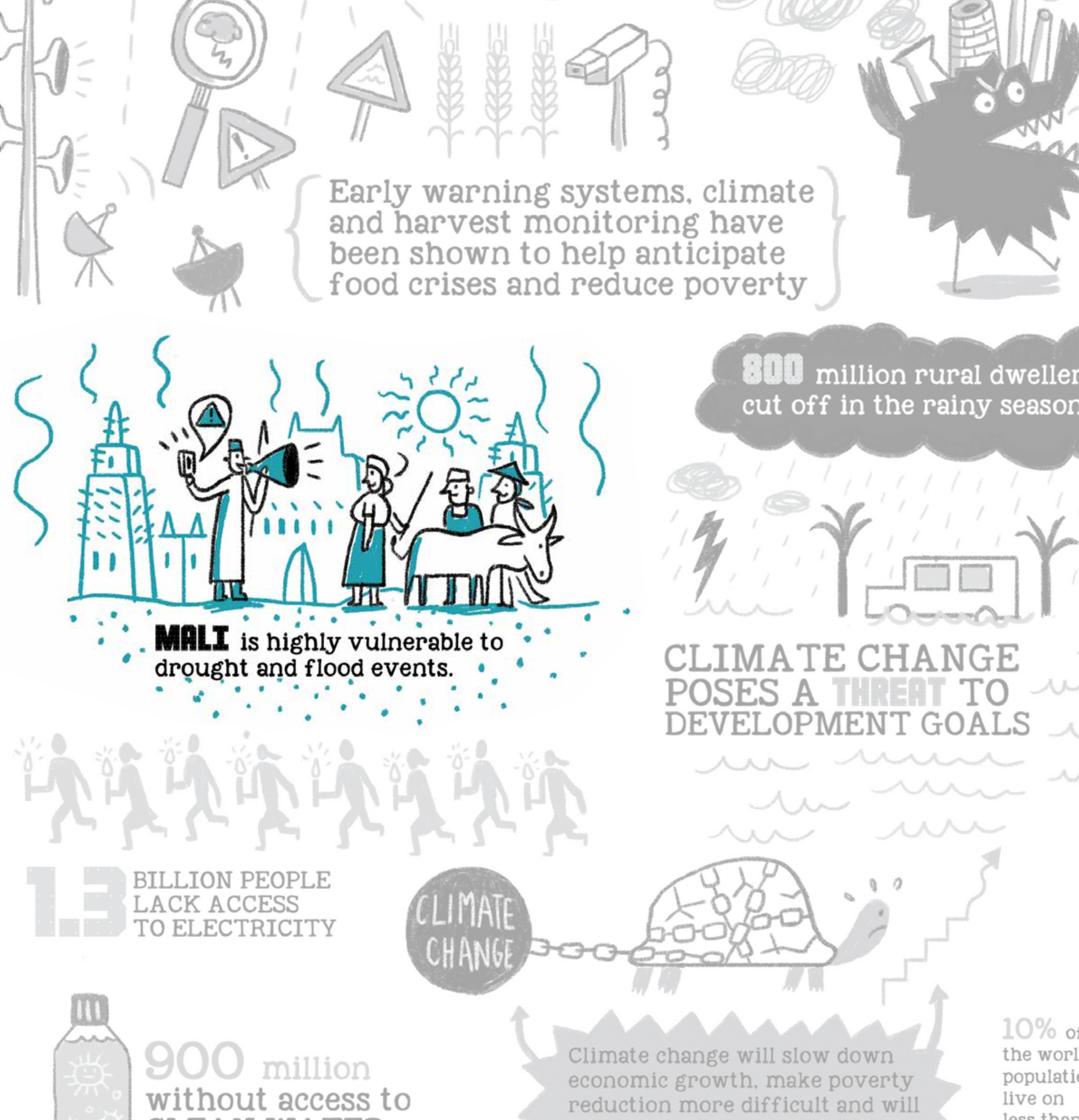
The 2015 heatwave in India is an example of one such climate extreme. May is the hottest month of the year across much of the country, immediately preceding the monsoon rains. In May 2015, heatwaves with incredibly high temperatures of 45 to 48°C were recorded in many cities and towns across the country, particularly in the south-central region (Burke, 2015). During each heatwave, extreme temperatures were sustained for days.

2.4.1 What is the role of climate change?

Evidence suggests a trend of increasing temperatures across much of India, with an increase in 'high temperature days' (greater than 37°C during March-June) since the 1990s in many places (Jaswal et al., 2015). Severe heatwaves have happened in the past in India, including very severe events in 2010, 2012 and 2009 (Jaswal et al., 2015). While the relatively short observational record has not (yet) reflected a statistically significant increase in the frequency of heatwaves in this region (Mishra et al., 2015), an increased frequency of warm days and reduction of cold extremes can point to increased risks (e.g. Panda et al., 2014; Jaswal et al., 2015). We expect the underlying mechanics of climate change to affect temperatures in this region, but there are other factors at play as well, including topography, changes in rainfall patterns and local air pollution. Paradoxically, the latter can have a cooling effect to counter-balance rising temperatures due to climate change (Kothawale et al., 2012).

Year-to-year climate variations, such as El Niño, can also affect heat and rainfall; El Niño years have been linked to late monsoons and widespread droughts in India allowing for extreme heat to affect the region before the cooling rains arrive (Kumar et al., 2006). The changing climate is also projected to affect the timing, frequency and intensity of rainfall across South Asia. Natural rainfall variations will continue to dominate year-to-year differences around the mid-21st century, but the longer-term trend is for increases in both the mean and extreme precipitation of the Indian summer monsoon. In addition, climate change may increase the year-to-year variability of monsoon rainfall across South Asia (IPCC, 2014a).

One important unknown is the relationship between climate change and the monsoon cycle (Turner and Annamaliai, 2012). Any change in the timing, intensity or frequency of the monsoonal rains in India could cause significant challenges if people are forced to cope with hot, pre-monsoon conditions over a longer period. This would be an added dimension to the uncertainty already faced across the region.



CHAPTER 3

Drought, complex shocks and poverty in Mali

Summary

The case of drought in Mali, underscores the complex and dynamic relationship between climate extremes, poverty and development. Climatic and political events like those experienced over the last decade present a considerable challenge for building resilience: efforts will have to face the dual challenge of tackling system-wide shocks with drivers that extend beyond national borders, while attending to the differentiated impacts of these shocks on poverty and wellbeing. Although rainfall has recovered to some extent since the end of the great Sahelian drought in the 1980s, it still remains well below levels during the four decades prior to the 1960s. With over three quarters of the workforce engaged in agrarian livelihoods, water stress is a driver of food as well as income insecurity. The central (Segou) region serves as an effective distribution hub for cereal production, with the pressures of both a changing climate and political uncertainty effectively expanding chronic food insecurity southward (Funk et al., 2012).

Analysis of rainfall patterns over the last century reveals a significant degree of variability. This is intrinsic to the hydroclimatic conditions of the Sahel. Yet climate models also concur that Mali will see a potential decrease in rainfall over coming decades due to anthropogenic climate change. This compounds growing human pressure on the major transboundary rivers, whose flows to some extent also regulate Mali's seasonal climate (Zwarts, 2010). Malians whose livelihoods depend on natural land, water, pasture, forest and fish resources in the inland delta region report experiencing more frequent drought cycles in the annual flood patterns upon which they depend because of development pressure from upstream abstraction and dams. The balance between human and natural drivers of poverty in this context is therefore complex. Continuing uncertainty regarding the localised impacts of climate projections within Mali only serves to reinforce the argument that effective responses must be robust in the face of likely climate extremes. Planning for an increasingly hot and variable climate as perhaps the most likely of a range of possible futures, would seem prudent. Key points to consider here are:

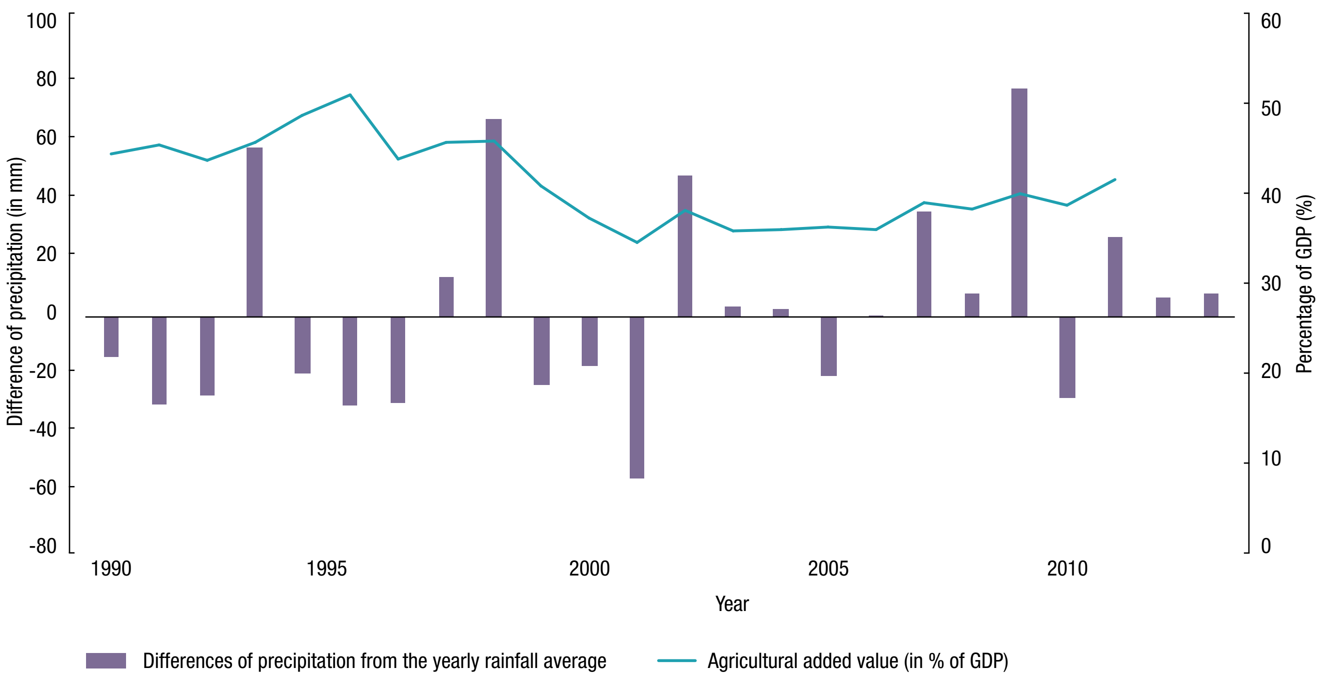
- As one of the ten poorest countries in the world, Mali is highly vulnerable to drought and flood events. Since the great Sahelian drought, it has suffered shorter and more unpredictable drought cycles, with a series of drought-related crises in 2010, 2011 and 2012.
- Mali is already experiencing climate change impacts on agriculture. Heat stress with a warming climate (conservatively estimated at a rate of over .2° Celsius per decade) has been projected to significantly reduce animal and plant production with consequent spikes in food prices if nothing is done to make Mali's agriculture more climate-resilient (Sogoba et al., 2014).
- The poverty impacts of water stress do not map neatly onto places where the climate signal is strongest, and are instead centred as much on areas where poor people are most exposed to fluctuations in food prices. This is illustrated in the cascade of shocks that occur when the crops that household food and income depend on fail, as shortages trigger food price volatility (Benson and Clay, 1998).
- Average rainfall remains consistently below levels from the period 1961–1990, causing fluctuations in the duration of the growing season. This in turn led to insecure agricultural production and degradation of the soil and vegetative cover, both of which are keys to restoration and intensification of climate-resilient production (Konate and Sokona, 2003).
- Despite the above, a number of initiatives – including technological innovations in agriculture, improved agrometeorological services, and better regional coordination for early warning systems – have been instrumental in reducing drought impacts on poverty and food security in Mali (Konate and Sokona, 2003).
- Early warning systems, climate monitoring and harvest monitoring have been shown to help anticipate food crises and reduce poverty, but there is, nonetheless, disconnect between the climate information systems and the interventions based on information provided (USAID, 2015).
- Lack of coordination across scales – from major transboundary river basin systems to national and decentralised municipal districts – has held back consideration of climate change risks in local development plans and undermined execution and scaling up of effective drought management strategies (Sogoba et al., 2014).

3.1 The impact of drought

The impacts of drought are complex and far-reaching, often spreading well beyond the place where drought occurs (Sheffield et al., 2014).[1] Consequences are compounded and shaped by the characteristics of the economic and agricultural systems of the affected area, as well as environmental factors (Benson and Clay, 1998). Droughts have short- and long-term consequences, along with direct and indirect impacts on the poor. Short-term consequences include drops in production and loss of food availability and livestock assets, triggering malnutrition and food insecurity. Longer-term consequences include chronic dependence on humanitarian assistance and stunting in children. Thus, drought effects on harvests and livestock production spread to impact on household income, food security and livelihoods. They also affect agricultural added value and GDP in countries such as Mali, which heavily rely on the agricultural sector (figure 6). These effects may be transitory but, depending of the size of the event and the sensitivity of the system, they can also have long-term consequences, pushing people or countries into poverty, and permanently degrading or reducing productive assets and human capital.

Through their impact on future harvests and farm incomes, droughts have a lag effect on the nutritional status of children. Sen (1981) describes how drought leads to reductions in income, with direct impacts on household welfare in the short and long-term, forcing households to reduce consumption and investments in their productive inputs and assets. In emergencies, households resort to selling productive assets, limiting their future income earning potential (Rosenzweig and Binswanger, 1993; Morduch, 1995). The consequences of reduced consumption for pregnant mothers and young children unfold over the long-term, resulting in nutritional stunting, worse school performance and lower life expectancy for children in comparison to their peers (Dercon and Hoddinott, 2003; Ferreira and Schady, 2009; Alderman, 2011). Climate impacts are also highly gendered, with girls often kept out of school to help in the household economy and girls are more likely to receive insufficient food during times of food shortage, in comparison to their male counterparts (Hadley et al., 2008).

Figure 6. Changes in precipitation and contribution of agriculture to GDP in Mali



The contribution of the agricultural sector to GDP in Mali is higher in years with higher rainfall, but this correlation is not perfect. This is due to the fact that the definition of drought is more complex than rainfall deficit and the overall economy can be affected by other shocks and stresses.

Source: World Bank (2015d)

1. UNISDR figures report that, in sub-Saharan Africa (SSA), droughts account for less than 20% of natural disasters but account for over 80% of the affected population (Sheffield et al.,2014).

3.2 Mali: droughts, shocks and poverty

Mali has one of the highest population growth rates in the world (World Bank, 2015a) and, in 2010, half its people lived on less than US$1.25 a day. On top of this, drought and conflict have increased the incidence of poverty in the country in the last five years (World Bank, 2015a). Recent events include a drought-induced crisis amongst northern pastoralists in 2010, a wider regional drought in 2011, and a regional political and security crisis in 2012 and 2013 that is still having lingering effects. In 2014, Mali ranked 176th on the United Nations Human Development Index (HDI) in 2014, putting it among the ten poorest countries in the world (Malik, 2014). The experience of Mali shows how recurrent droughts, combined with governance, security and resulting economic shocks, can create a complex set of dynamics that entrench poverty and undermine resilience from the household and community levels through to national scales.

The EMDAT international database of disasters recorded 5,125,000 people in Mali being affected by drought over the course of five major events from 2000–2015 (Guha-Sapir et al., n.d.). Since records are not consistent over the last 20 years, this number cannot be compared with earlier major droughts in the 1980s and 1990s. For example increases in the number of people affected by drought over time may reflect improved tracking of drought impacts, as well as growing vulnerability to drought. The measurement of direct and indirect drought impacts remains a challenge, as does assessing drought-related losses. The difficulty in measuring indirect impacts in particular is a barrier to understanding whether resilience is dropping or data collection is improving.

Reported linkages between water stress, food security and political security (Arsenault, 2015) are backed up by a growing body of literature. The Brookings Institute has published a study showing that for each 1% change in average temperature and rainfall, there is a corresponding 4% increase in the frequency of cross-border violence (Kälin, 2008). Meanwhile, intergroup violence, such as that which plagues Mali, goes up by 14%. This study foresees an explicit link between climate change and conflict:

> "A decrease in essential resources due to climate change (water; food production) most likely will trigger armed conflict and violence: This is most likely to affect regions that have reduced water availability and that cannot easily adapt (e.g. by switching to economic activities requiring less water) due to poverty. These armed conflicts may last for as long as resource scarcity continues. This in turn would impede the chances of reaching peace agreements which provide for the equitable sharing of the limited resources and thus prolong the conflicts, leading to more situations of protracted displacement" (Kälin, 2008).

Population and political pressures fuelled by water and heat stress put growing pressure on fragile, overexploited and poorly managed natural resource systems. Inter-communal conflict is of increasing concern north of the inland delta in Mali, where pastoralists face an influx of people from other regions. Some of these displaced people are drought-driven and in need of grazing land, while others have domestic or wider political and militant motivations. It is also possible that some (of each of these groups) exploit the instability created by insurgency to engage in criminal activity.

3.2.1 Recurrent drought-related shocks

Agriculture accounts for 40% of Mali's GDP (World Bank, 2015a). Agro-pastoral production depends on one rainy season and one crop cycle each year, making the country highly vulnerable to drought and flood events (FEWS, 2015a). The country's northern zone is characterised by pastoralism, its central zone by sedentary integrated cereal-livestock production systems and its small south western zone by sedentary cotton-cereal-livestock production systems. With 80% of the population engaged in agriculture, only 7% of 43.7 million arable hectares are currently cultivated, and only 14% of 2.2 million potentially irrigable hectares currently irrigated. Mali's economy relies heavily on rainfed agriculture and livestock production, and almost 30% of the population is malnourished (USAID, 2015).

As the rainy season began in late 2011, uneven rainfall distribution once again led to weak rainfed crop development and widespread low cereal yields

The majority of Mali's agricultural land area lies in the Sahel where, as already discussed in chapter 2, rainfall is extremely variable. Prolonged periods of low rainfall during the 1980s and 1990s had significant food security consequences, and rainfall levels continue to decline. Two years of low and erratic rainfall, in 2008 and 2009, led to a crisis amongst Mali's pastoralists in 2010. Insufficient regeneration of northern pastures after the dry season and the resulting biomass deficit limited livestock development, and pastoralists were forced to begin their seasonal migration prematurely and move unusually far. Many livestock perished, and mass destocking in order to limit further losses led to a glut of livestock in the market. A consequent sharp drop of about one third in livestock prices in turn led to a reverse in the livestock-cereal exchange rate, which affected the entire Sahel region (Réseau Billital Maroobé, 2010). The pastoralist crisis thus resulted in a decline in the income and assets of not only the pastoralists, but also the sedentary smallholder farmers.

A year later, West Africa was again widely affected by erratic rainfall, with the result that the 2011 cereal harvest in Mali was down by 54,420,000 tonnes (about 10%) on the previous year (CILSS, 2012). The World Food Programme reported 60% of Malian households surveyed after the rainy season had no harvest at all (Diarra and Togola, 2012). On average, agricultural production for the 2010/2011 season covered only three to four months of the country's food needs, down from six to nine months in a 'normal' year.

Some consequences of drought continue to be felt in the ten months following the rainy season, especially during the dry season a year after a production deficit that was triggered by low rainfall (FEWS, 2015a). Thus, as the rainy season began in late 2011, uneven rainfall distribution once again led to weak rainfed crop development and widespread low cereal yields. There was almost no harvest in the cotton-cereal-livestock-producing Sikasso region in the far south west, usually the wettest area of the country. In the north western, Sahelian area, where Mali borders Mauritania, low and unevenly distributed rainfall caused both a drop in agricultural production and a shortage of forage, negatively affecting household incomes.

Access to food became a major problem across the whole of the Western Sahel during the 2011/12 drought. The drop in production led to price spikes affecting food access for the more vulnerable. The World Food Programme (Diarra and Togola, 2012) identified five particularly vulnerable groups: landless farmers, pastoralists without livestock, nomads being settled into farming activities, women and children. The lack of production also transformed poor farmers, reliant on subsistence production, into net buyers of cereals. Poor people living in urban areas were also affected through the reduction in food availability and rising prices linked to shortages.

The impact of this food crisis was compounded by political instability, conflict and weak governance, with a military coup in March 2012 and the subsequent rebellion of Tuaregs and militant Islamist groups, which put the north of the country beyond the control of the national government (World Bank, 2015a). By April 2012, at least 270,000 people and their livestock had been displaced by the conflict, with over 161,000 going into neighbouring countries such as Burkina Faso, Niger and Mauritania. Nearly 100,000 cattle are thought to have been driven across the border into Burkina Faso, aggravating the risk of conflict over increasingly scarce natural resources such as pasture and water (CILSS, 2012). By the end of the year, most of the population of northern Mali was classified by FEWS, the Sahel region's Famine Early Warning System, as food insecure (FEWS, 2015b), not least because the conflict had limited humanitarian responses to the drought.

By March 2014, 1.5 million people were still considered food insecure in Mali. During that dry season, 40% of people in the north of the country were facing difficulties in finding their next meal (WFP, 2014). In 2015, across the whole country, an estimated 660,000 children were believed to be at risk of acute malnutrition, with 25% of Malian households considered as food insecure – around 40% in the north of the country. A survey conducted in March 2015 by the World Food Programme defines the country's food insecurity as structural, driven by the poverty situation in conjunction with climate, political and social crises (WFP, 2015).

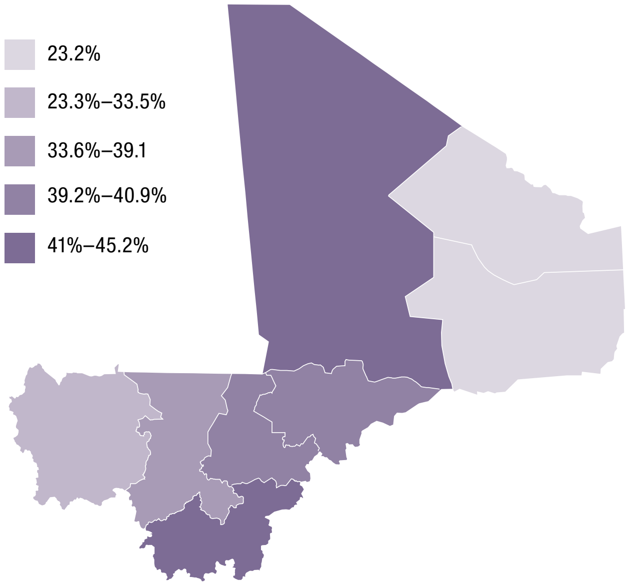
3.3 A complex relationship between drought and poverty

The compounding impact of the shocks described above is a significant driver of Mali's current national poverty situation. The World Food Programme Surveys of the 2012 and 2015 droughts established a clear link between these drought events and levels of poverty (WFP, 2012; WFP, 2015), but the impacts of drought appear not to be limited to the geographic location where the drought occurs. The two maps in figure 7 compare the geography of malnutrition prevalence in Mali (in 2006) with the geography of high exposure to drought events (for the period 1981–2010). These maps show there is no clear geographical co-location of the two phenomena: there are no obvious 'hot spots' where climate extremes and poverty intersect.

Figure 7 shows that children's height-for-age z-score

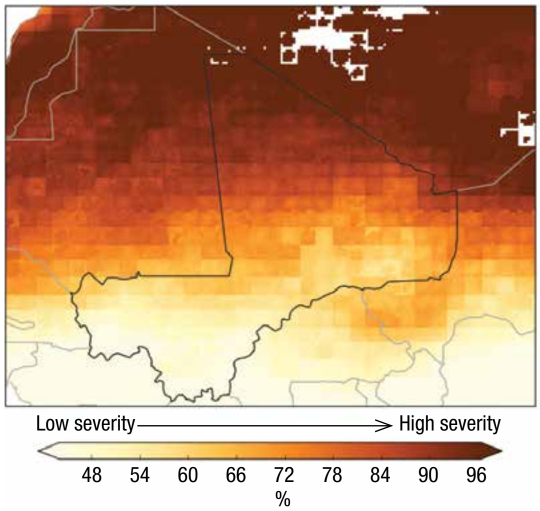
Figure 7. Geography of malnutrition and drought in Mali

Percentage of child population that are stunted in 2006



Source: Author calculation based on data from Demographic Health

Geography of average drought severity (for the period 1981–2010, in %)



Map based on 1981–2010 daily rainfall data from Era-Interim (Dee et al., 2011) and calculated using the Moving Average Precipitation Variable Threshold drought indicator (Wanders et al., 2010). An event of 100% severity indicates no rainfall during the identified drought days. Drought calculation severity is relative.

(HAZ) indicator, a proxy for long-term nutritional status (Linnemayr et al., 2008), was high throughout the country in 2006, at more than 20% in all regions. The distribution of stunted children in the population was particularly high in the north and extreme south.[2] The 2006 situation presented is representative of structural food insecurity over the period 2001–2006 (the HAZ-score is a stock variable along the life of the children and we are focussing on those under the age of five). Several sensitivity tests have been performed to define poverty using drought indicators (such as average length of drought or average severity), but the geographical correlation between poverty and average length of drought over time remains low.

Care should be taken in interpreting this however, as the map used here to represent drought is only one measure of this phenomenon and highlights the relative characteristics of drought for each location. The drought indicator values are relative to climate characteristics of each region and so whilst the percentage severity is greater in the North, more rainfall is expected in the south (on average) and so a less severe drought here may actually have a greater impact on the local population.

Moreover, the geographical distribution of chronic malnutrition does not correspond directly to those areas that experienced the most severe droughts between 1981 and 2010 (according to the measure of drought used here). The drought map shows that there are no specific "hotspots" of drought over Mali with this indicator and in general the whole country will be affected by drought at the same time, as these are often regional-scale events. The areas with the highest share of stunted children do not therefore correspond to areas of particularly high drought intensity.

The fact that there is no simple geographical correlation between the two phenomena also suggests a more complex picture in terms of vulnerability to drought. Young children of farming families least habituated to severe drought may be more vulnerable to drought extremes, while families more accustomed to drought may exhibit some degree of resilience to stunting. The analysis of the map does not take into account migration of families and individuals away from affected areas (often to urban areas), and remittance flows from urban to rural areas that may serve to mitigate losses for rural households (Benson and Clay, 1998). Overall, understanding the sensitivity of the systems which people rely on (e.g. food access, economic activity, and

2. The height-for-age indicator measures the long-term nutritional status, the indicator reflects the chronic malnutrition and the stunting status. Height-for-age z-score is a proxy of health stock reflecting current and past health investments (Linnemayr et al. 2008). We consider this indicator a good proxy for poverty as the structural nutritional status in Mali is mainly driven by poverty (WFP, 2015). The height-for-age z-score indicator is calculated as the difference between the child's height-for-age and the median height-for-age for the same aged reference population divided by the standard deviation of the reference population.

water availability) would help us to better understand the complexity of the relationship between climate and poverty in Mali.

While the map of the distribution of stunted children is arguably a good proxy for vulnerability and sensitivity of households to the effects of poverty, drought clearly affects whole economic systems, meaning its effects on vulnerable households are spread throughout the economy. Households are just as likely to be impacted in urban or densely-populated areas, where demand is sensitive to food price fluctuations and cereal availability, as places where high numbers of drought days have a direct impact on agricultural production. The effect of drought on the incomes and food security of smallholder farmers is complex and depends on whether they are net sellers of produce or subsistence farmers, as well as the size of the drought and how drops in production are reflected in prices. If the drought leads to higher prices, farmers who are net sellers can obtain higher benefits. This is less likely to happen for subsistence farmers however who will become net buyers of cereal after a drop in production and will be directly affected by price spikes and lack of access to cereal. The effect on the household economy is clearly different in each case and appears to have more to do with the coping strategies that are available. Initiatives geared towards building resilience to drought should not only focus on drought location areas but also on the need, as well as opportunities, to build resilience across the system.

3.4 Building resilience to drought

The agricultural sector is the foundation of Mali's economy but nonetheless suffers from low productivity, post-harvest crop losses, under-developed markets and vulnerability to climate change. However, the potential for agriculture growth and expansion, driving more broad-based economic growth, is promising (USAID, 2015). A number of initiatives have been instrumental in reducing the impact of drought on poverty and food security in Mali. These include agricultural innovation, weather monitoring and the development of early warning systems for Mali and the whole of the Sahel. The following section highlights initiatives that have been important in anticipating, absorbing and adapting to the impacts of drought. These include:

- sustainable intensification through drought-tolerant seeds and water resource systems management, soil-building and fertiliser management
- risk management measures, including Weather Index Insurance, early warning/early action systems and climate information, social protection and safety nets
- value chain development, through input/output market improvements and livelihood diversification, including moving up and out of agriculture.

3.4.1 Technological innovation to strengthen resilience to drought

Poverty alleviation is directly linked to agriculture, whether in the form of drought-resilient crop varieties, improved livestock breeding or changes in farming practices and planting choices. Agricultural technologies have the potential to significantly boost production and reduce spoilage and loss due to risks such as pests and pathogens. They also improve the nutritional quality of food grown and consumed by farming households (Kelsey, 2013).

The development and adoption of drought-tolerant crop varieties, for example, allows farmers to better manage drought and has already proved effective in mitigating some of its impacts (Shiferaw et al., 2014). Drought-tolerant crops such as pearl millet, cowpea, groundnut and sorghum, along with crops with drought-tolerant varieties like maize, can optimise production in contexts where water for agriculture is limited (Xoconostle-Cazares et al., 2010). However, realising the potential gains from the use of drought-tolerant crops and varieties depends on farmers adopting new seeds and cultivars. This, in turn, relies on them being available on time and at affordable prices. While current trends show an overall growth in the adoption of improved crops, sub-Saharan Africa lags behind other parts of the world (Kelsey, 2013).

The impacts of drought can be managed all along the agricultural value chain, but crop production is one of the most exposed and sensitive segments, with many constraints impeding adoption of new technologies. Identifying the constraints and which can be effectively reduced or removed, can serve as a framework for assessing the viability of new technological approaches and help build enabling environment for adoption.

3.4.2 Informing to anticipate: the National Meteorological Agency

When to plant is the most critical decision to make in crop agriculture, followed by a series of cultivation decisions traditionally timed according to local weather and biological indicator systems. Due to a changing climate and especially as a consequence of decades of Sahelian drought, many traditional indicator species used by farmers in the past have now died out and weather patterns are unlikely to return to any prior 'normal'. The need for crop calendars led Mali's national meteorological service in the 1980s to begin to develop fairly sophisticated agro-hydrometeorological forecasting for different crops and regions. While use of these forecasts for planting and cultivation has contributed to some recovery in the agricultural sector, there is always room for improvement in making such advisories more accessible and actionable by farmers.

In recognition of this, the National Meteorological Agency in Mali (Mali Météo) is now involved in a broad programme of meteorological assistance for agriculture. The aim is to respond to farmers' needs in terms of limiting risk and loss, decreasing the cost of production and improving productivity. Since 2001, local and communal Meteorological Assistance groups have been created in different parts of the country. These groups, backed up by the Multidisciplinary Working Group for Meteorological Services in Rural Areas (WGIP), support the production and dissemination of agro-meteorological products and information about the evolution of each agropastoral season. To date, over 1,800 male and female farmers have been trained in rainfall recording and crop observation, while more than 500 advisers have been trained to provide them with guidance developed by the WGIP. The programme has already yielded important results, helping to anticipate climate and production stresses and adapt practices and production accordingly (USAID, 2014b).

> **Recent work has resulted in the development of a harmonised framework for the analysis and identification of high-risk areas and vulnerable groups across the region**

Soil nutrient depletion is a major barrier to improving crop yields in Africa. Rainfed production systems do not allow a systematic optimisation of fertiliser, because of rainfall variability (Dimes et al., 2003). Adaptive fertilisation management relies on a better understanding of rainfall distribution through seasonal climate forecasting. If such information was available and used effectively, it could also translate into more efficient management and use of both water and soil nutrients (Holden and Shiferaw, 2004).

3.4.3 Regional institutions and agreements to anticipate and absorb

Efforts towards more coordinated regional action to anticipate and absorb the impacts of drought have been ongoing since the founding of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), in the wake of the great Sahelian drought of 1973. Recent work has resulted in the development of a harmonised framework for the analysis and identification of high-risk areas and vulnerable groups across the region. Through this framework of regionally integrated drought management information, CILSS produces a regular early warning system newsletter on the cereal production situation and seasonal rainfall projection, which also includes an assessment of food security. This helps keep policy-makers and communities informed, target sensitive areas and highlight future food security challenges. CILSS also provides technical support and training to policy-makers through Agrhymet (CILLS, 2012).

Mali's membership in the Economic Community of West African States (ECOWAS) and the West African Economic and Monetary Union (UEMOA) means its food security situation and economic stability depend not only on its own agricultural production, but also on that of neighbouring countries. Regional economic integration should help ensure food security by:

- smoothing shocks through enabling access to food in areas facing deficits
- promoting agricultural price stability
- increasing farm income

(Brunelin and Portugal-Perez, 2013).

ECOWAS and UEMOA also work with CILSS through the Food Crisis Prevention Network (RCPA); this coordination at the regional scale helps anticipate and produce a coordinated response when crises occur.

This combination of early warning systems and monitoring of climate, harvests and prices has helped prevent food crises in Sahel region (Brunelin, 2015). However, assessing a crisis situation in time does not always result in timely interventions and emergency response measures, for several reasons (Brunelin, 2015). The traditional focus on food production indicators to prevent food crises, instead of an overall assessment using prices as early warning indices at the national level, provides part of the explanation (Bonjean, 2010).

This focus is changing, however, and price indices are now being more systematically integrated at the national and regional levels. Nonetheless, the integration of market information in drought prevention still faces challenges regarding the availability and quality of data, lack of a regional approach to data analysis and complexity of using price information to detect and anticipate a crisis.

The focus of early warning and drought monitoring systems are primarily at the national level and on the agricultural sector, which partly accounts for the delayed response to the 2010 crisis (RBM, 2010). Lack of monitoring of the livestock sector, along with a more general lack of sub-national targeting and reports reflects the remote geographic location and low geo-political importance of pastoralist livelihoods. These livelihoods have faced a long-standing bureaucratic and policy bias across the Sahel, undermining the suitability of this mode of life and livelihood, for vast regions under increasing water stress in the context of climate change.

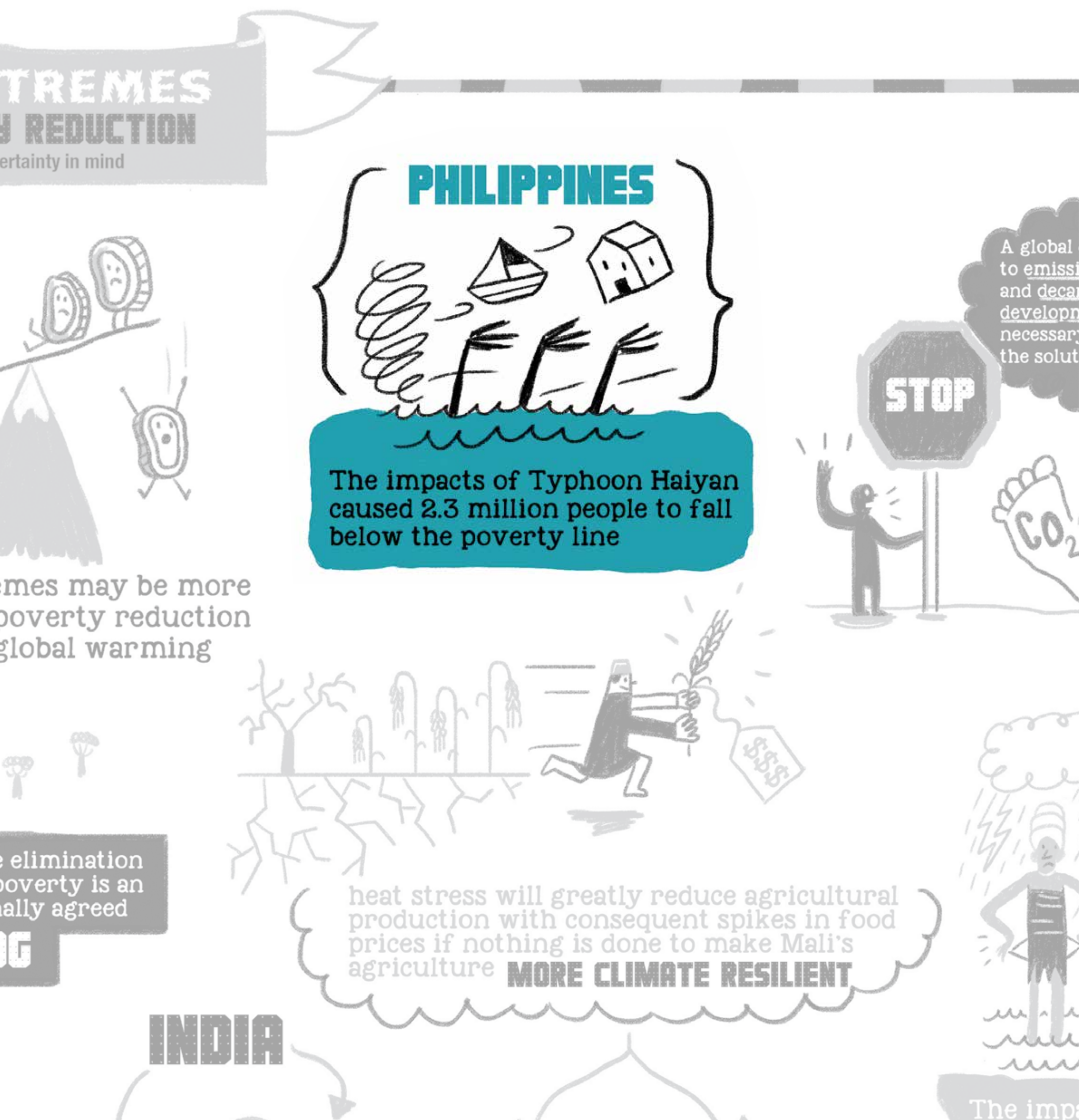
The lack of coordination between regional, national and sub-national entities on risk management measures is also an important challenge. Vulnerability analysis at a sub-national level remains poor and does not enable efficient targeting when a crisis does happen. To date, decentralised authorities do not have drought management responsibilities. They also lack the human and financial means to support coordinated action or play a linkage role in managing droughts or other disasters.

Finally, the recurrent nature of crises and drought periods described in the previous section is also a major challenge for the sustainability of drought and food crisis management systems. In the Sahel, a good harvest seldom compensates for the past year's severe drought; in Niger, for example, households need three years, on average, to fully recover from a drought (Ballo and Bauer, 2013). Crisis interventions covering one agricultural season cannot tackle an accumulation of shocks, meaning the long-term consequences of drought challenge the utility of traditional early warning systems.

3.5 Future climate change: geographic and socio-economic inequalities

Looking forward, Mali faces continued climatic and socio-economic uncertainty. Most climate models project an increase in temperature and annual rainfall across the Sahel, as well as more intense precipitation events (Niang, et al., 2014). Projections of the magnitude of change that Mali is likely to see differ between models, as do predictions of the direction of change from region to region within the country. It is important to note, however, that the dynamic and sensitive nature of the climate in West Africa, as well as the region's high levels of exposure and vulnerability to climate risk, means even small changes in the climate could have significant impacts on local populations and development. The case of drought in Mali underscores the complex dynamics between recurrent drought and its impact on poverty and development. However, it also highlights the progressive onset of climate changes if global emissions remain insufficiently in check. These could exceed the biological tolerances of adaptation for crops and even livestock in large parts of Mali, requiring a much greater emphasis on intensification of production in the fertile and irrigable river basin regions of the country. This would also necessitate a concomitant emphasis on diversification of livelihoods for populations in the most heat and water-stressed parts of Mali in the future. The factors determining these dynamics – which range from the changing climate to international commodity prices – are numerous. They are also often beyond the influence of communities or governments (Benson and Clay, 1998). As such, efforts at building resilience face the dual challenge of tackling system-wide shocks with drivers that extend beyond national borders, while attending to the highly differentiated impacts of these shocks on poverty and wellbeing.

The continued uncertainty around climate projections in Mali only serves to reinforce the argument that effective responses, including those described in this chapter, must be able to accommodate a range of possible futures. Moreover, monitoring systems must be in place to track the evolving climate pressures and associated impacts. These must then adjust adaptation strategies accordingly. It is important to emphasise that adaptation is not a one-off activity, but dynamic and open-ended. The example of the difficulty of attributing impacts such as early childhood stunting, to a particular climate factor such as drought length, is indicative of the complexity in developing practical diagnostic, monitoring and measuring frameworks for resilience.



CHAPTER 4

Poverty impacts of tropical cyclones in the Philippines

Summary

The Philippines experiences over 18 tropical cyclones each year, with nine that cross land and three that are potentially disastrous (Birkmann et al., 2014). Exposure to storm surges is expected to increase, due to rising sea levels and this together with potential increases in cyclone intensity, is likely to have a strong impact on poverty across the country. This will threaten the lives and livelihoods of the millions of Filipinos who live in coastal areas, and is likely to undermine recent development gains and economic growth. Building resilience to future storm surges and cyclonic activity requires investments in Disaster Risk Management that are sensitive to the needs of the poorest, particularly those living in informal housing in coastal cities. Along with this, inclusive development must support the capacities of coastal populations to face future risks. Crucial points to consider in relation to this are:

- In 2013, Super Typhoon Haiyan made landfall in the Philippines, killing 7,300 people, displacing 4.1 million and also impacting on agriculture- and fishing-based economies (GFDRR, 2014).
- Although nationwide economic growth rates were not affected in 2014, at the local level, Haiyan led an additional 2.3 million people to fall below the poverty line (GFDRR, 2014).
- Every level of government in the Philippines has its own disaster risk reduction and management council or committee (Fernandez et al., 2012).
- Anticipatory responses in advance of Haiyan's landfall substantially reduced deaths, but also high-lighted a number of gaps in disaster preparedness planning (Oxfam, 2013; Ocon & Neussner, 2015).
- After Haiyan, new initiatives to mitigate future cyclone exposure included mangrove reforesta-tion and the declaration of a no-dwell zone within 40 metres of the coast (De Vera, 2013).
- Solutions are needed to build the adaptive capacity of the urban poor living in low-lying areas, and those whose livelihoods depend on access to the coast.

4.1 Tropical cyclones and poverty

Tropical cyclones are one of the costliest types of climate hazard and have the potential to produce large numbers of casualties (see figure 8). Over the past two centuries, cyclones have been responsible for approx-imately 2 million deaths (Penuel and Statler, 2011). The heavy rainfall, wind gusts and storm surges that accompany tropical cyclones can be highly destructive to low-lying coastal areas, causing extensive property damage and numerous deaths by drowning. Although it is not clear how patterns of cyclonic activity will alter under climate change, observations have demon-strated that tropical cyclones have become more intense since 1982 (Kossin et al., 2013).

On average, the Philippines experiences more than 18 typhoons each year, making it the second most hazard-prone country in the world (Birkmann et al., 2014). Increasing sea levels, combined with potential increases in cyclonic intensity are likely to amplify the impact of tropical storms to the Philippines, and threaten the estimated 40 million Filipinos who live in coastal areas. These hazards jeopardise the Philippines' consistent economic growth, which has positioned the island nation amongst the best performing economies in Asia (Government of Philippines, 2015). Even with rapid economic growth, the Philippines' poverty headcount hovered over 25% in 2012, and the most vulnerable remain highly exposed to disasters. In Manila alone, over two thirds of poor households already suffer regular losses from cyclones, floods and storm surges – a figure that is likely to increase with sea level rise, maladaptive land use and uncontrolled expansion into exposed areas (Pillai et al., 2010).

On 8 November 2013, Super Typhoon Haiyan made landfall in eastern and central Philippines, breaking records for being the strongest ever recorded storm and creating a trail of devastation in the path of the five-metre high storm (Munich Re, 2014). The ensuing humanitarian emergency left upwards of 7,300 people dead and 4.1 million people displaced after their homes were damaged or destroyed (GFDRR, 2014). Agriculture and fishing-based economies, the main sources of livelihood for affected populations, were wiped out. Health and education service infrastructure sustained significant damage, with over 3,000 schools partially or completely destroyed (World Bank, 2014). The scale of the damage was immense, testing the limits of response operations and the capacity of government to support communities to recover.

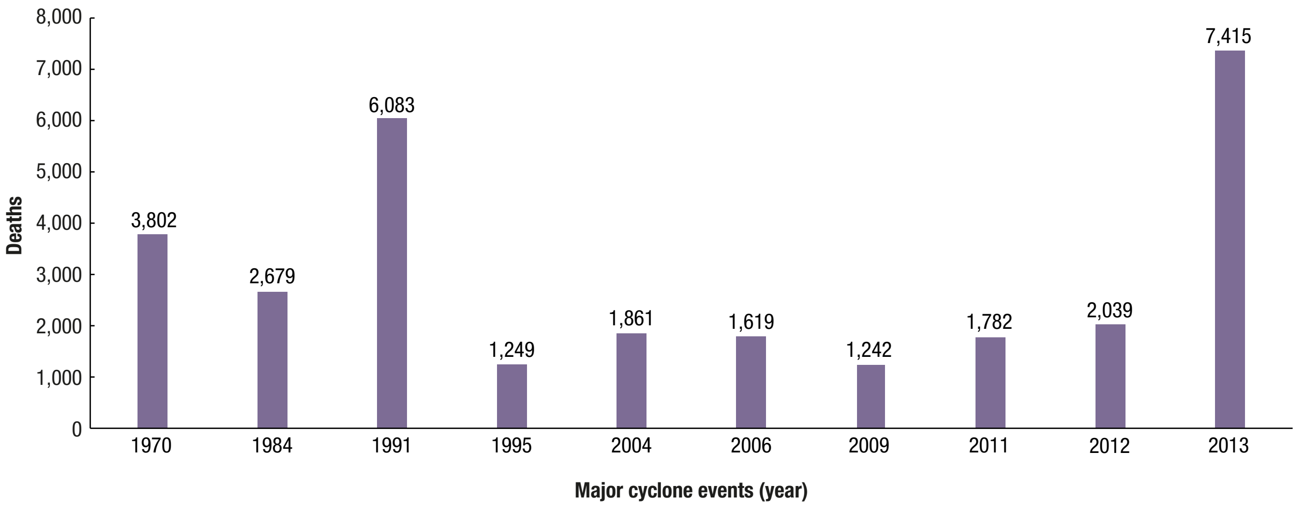
Macro-level economic indicators disguise a more worrying story about the impact very strong cyclones can have on poverty at the subnational level. While the worst-affected areas struggled to recover their assets, nation-wide economic growth continued rapidly, with a 6.5% GDP growth rate in the last quarter of 2013, making the Philippines the best performing Asian economy after China (Lopez, 2014). Haiyan did not appear to affect growth rates in 2014, which remained strong at 6.9% (World Bank. 2015d). Meanwhile, ongoing reconstruction efforts and increases in remittances are expected to provide a boost to overall performance into 2015 (Wyatt, 2014).

At a local level, however, the effect of the cyclone on poverty and livelihoods was immense. In the Eastern Visayas, where Haiyan first made landfall, over 45% of the population was living in poverty before the storm hit. Here, the city of Tacloban was destroyed, affecting millions of people. A post-disaster assessment by the Global Facility for Disaster Reduction and Recovery found the disaster pushed an additional 2.3 million people, nearly 500,000 households, below the national poverty line. In the worst-affected areas, the poverty rate rose to over 50%. Self-reported poverty rates one month after the disaster were even higher: 70% of victims rated themselves as poor compared to approximately 50% of the rest of the country (Social Weather Station, 2014). This can be largely attributed to Haiyan's impact on the fishing and farming industry. Nearly three quarters of households experienced a decline in their livelihood situation after the typhoon, with fishers and coconut farmers experiencing the most difficulty (Sherwood et al., 2014). The increased cost of living after the disaster put even more pressure on poor households. Over 405 of households affected lost their primary source of income (ILO, 2014). Economic losses in the wake of Haiyan were enormous for displaced survivors, most of whom lost productive assets, had no access to jobs and lost their homes (Sherwood et al., 2014).

4.2 The ongoing challenge of building resilience

The Philippines has a long history of coping with disasters and the Disaster Risk Management system has evolved and undergone improvements after major events in response to public demand (Ocon and Neussner, 2015). In 2010, a new disaster reduction and management law (Republic Act 10121) was introduced, in which the government officially adopted community-based DRM as a principle for dealing with disasters, supporting local capacity to respond to emergencies and decentralising DRM functions to local government units. Every level of government – national, regional, provincial, city, municipal and barangay – has its own disaster risk reduction and management council

Figure 8. Cyclone mortality in the Philippines



or committee (Fernandez et al., 2012). The community-based DRM approach has been heralded as a successful strategy, with local people participating in DRM councils for preparedness and response planning, and some barangay even undertaking participatory budgeting for DRM. On paper, the institutional arrangements that have been designed to manage risk are strongly rooted in principles of public accountability and equitable delivery. However, varying levels of capacity and corruption at different levels of government have compromised the effectiveness of the DRM system in supporting vulnerable populations (Diola, 2015, Thura, 2013).

Varying levels of capacity and corruption at different levels of government have compromised the effectiveness of the DRM system in supporting vulnerable populations

Overall, the focus of DRM efforts has been on improving early warning systems and preparedness, with anticipatory actions proving to be effective for Typhoon Haiyan, substantially reducing loss of life. The municipal authority of San Francisco, which was directly in the path of Haiyan, evacuated an entire small island and managed to save its inhabitants (Rananda, 2014). At the national level, the President of the Philippines went on national television in the week leading up to the storm to warn the public, an intervention that has been credited with triggering mass evacuations that saved many lives.

The response to the crisis was broadly considered to be effective, demonstrating high levels of coping capacity in the Philippines, even in the face of such a high-intensity event. Two months after Haiyan, a poll of survivors in Eastern Visayas region showed that 79% of survivors were satisfied with the local government response to Haiyan and 77% were satisfied with the national government's response (Social Weather Station, 2014). The international community also played a large role in emergency response – affected communities were inundated with cash transfers designed to expedite recovery for households that had lost their possessions in the disaster. Cash transfers constituted approximately 40% of all response spending. About three quarters of transfers were conditional or provided through cash-for-work programmes, mainly supporting livelihood rehabilitation for the poorest families. Favouring cash over physical goods allowed households to make decisions suited to their own recovery. These cash transfers and private remittances lessened the typhoon's impacts on jobs and output in the absence of a comprehensive social safety net for survivors.

Despite these significant achievements, Haiyan highlighted a number of gaps in disaster preparedness planning. Many residents in affected areas did not understand the term 'storm surge' used in the early warnings. According to interviews with survivors, the terminology was not associated with the tsunami-like effects that followed (Libessart, 2013). This lack of comprehension had serious consequences. According to a Gesellschaft für Internationale Zusammenarbeit (GIZ) study, an estimated 94% of casualties in the three most heavily affected cities were due to the storm surge (GIZ, 2013). Furthermore, some evacuation centres were badly located for a storm surge of Haiyan's magnitude. In Tacloban, thousands of people stayed in an indoor stadium designated as an evacuation centre. Though the roof stayed on, a 6-metre surge of water flooded the structure and killed the people sheltering inside. This indicates clear lessons for improving disaster preparedness, in particular, the importance of using risk assessments in preparedness planning. Extreme events of this scale and intensity will happen again and lessons must be learned each time about how to improve mechanisms for raising awareness, alerting populations and managing evacuations and shelters. However, these efforts will not save all human life and property, as these apparently rare events become more frequent and human exposure to them continues to rise (Mendelsohn et al., 2012). Building resilience to cyclones, storm surge and flooding in the Philippines will need to tackle the root causes of increasing exposure and vulnerability, better accommodate extremes and focus attention on the most vulnerable groups.

Overall, efforts to build long term adaptive capacity are less prominent in local planning than preparedness and response measures. Early warning systems and evacuation plans are important for reducing mortality but do not constitute a holistic DRM strategy (Wilkinson et al., 2014) and notwithstanding these efforts to prepare, response and recovery after a disaster still constitutes the majority of the Philippines' DRM budget. At the start of 2013, 54% of public DRM funds had already been allocated to response and recovery. Recognising the need for more proactive measures to reduce climate risks, the government allocated PHP

13.7 billion ($293 million) in 2014 to a National Disaster Risk Reduction and Management Fund, replacing the Calamity Fund which had about half the budget and was focused on post-disaster activities (McElroy, 2013).

In the Philippines, exposure to cyclones is driven by a number of factors, including the following:

- Rapid urbanisation results in the urban poor living in hazardous places where land is cheaper, such as flood plains or unstable slopes. Houses are generally constructed with poor-quality materials and are both uninsured and untitled. The urban poor tend to work in the informal sector and have few assets to help them absorb the impacts of disasters (World Bank, 2010). This result could be seen after Haiyan, as the poorest lacked alternative sources of income when their livelihoods were affected.
- Mangrove deforestation across the Philippines has increased exposure to storm surge. In the worst-affected areas of Eastern Visayas, mangroves had been cleared out, removing a natural barrier and leaving the storm surge to sweep over low-lying areas unobstructed. The Secretary for the Department of Environment and Natural Resources (DENR) estimated that up to 80% of the storm surge's strength would have been dissipated had mangrove forests been healthy (DZRB News, 2013).

Lessons from Haiyan have had some influence on longer-term planning: the Government of the Philippines has recognised the role mangroves play as a natural defence and the DENR has pledged PHP 347 million ($7.4 million) to develop mangrove forests in the Eastern Visayas (DZRB News, 2013). Yet despite the magnitude of the impact on poverty levels, surprisingly little attention is being paid to strengthening the adaptive capacity of at-risk communities, including through the diversification of incomes away from activities highly sensitive to high winds and flooding. A small number of NGOs have stepped in with programmes to help communities consider options for diversification, such as through community-based sustainable tourism. However many more NGO cash for work programmes aim to support and rehabilitate – rather than diversify – affected livelihoods (Brown, 2015).

In 2013 the Government of the Philippines declared a no-dwell zone within 40 m of the coast in order to reduce exposure to similar climate extremes in the future. The law prohibits construction in an effort to reduce the vulnerability of coastal dwelling populations to future storm surges (De Vera, 2013). Many poorer fishers have not adhered to the law, as it has a disproportionate impact on their livelihoods (Eadie, 2015). Among those Visayan householders who were affected by Typhoon Haiyan, 91% reported that they would rebuild their homes in the original location; without other land available, many survivors felt they had no choice but to re-expose themselves to high risks.

Municipal planning in Tacloban has attempted to provide alternatives for poor people to facilitate better adaptation to future climate risks. City-wide plans for disaster-resilient reconstruction has included the creation of about 1,000 new homes in safer settlement sites north of the city, as well as retrofitting important social and physical infrastructure along the coast (Tacloban Recovery and Sustainable Development Group, 2014). Shifting land use away from lowland development is clearly important for reducing exposure and sensitivity to future typhoons, but early surveys conducted one month after Haiyan have already shown that poor people are willing to assume high risks in their land choices in order to live near the source of their livelihoods. Reducing exposure must be balanced with the needs of fishers and agriculturalists to practice their occupation and make a living. Applying the lessons of Haiyan to future disasters across the Philippines means an increased focus on improving anticipatory capacity of the poorest, ensuring they can adapt to future climate extremes without compromising their livelihoods.

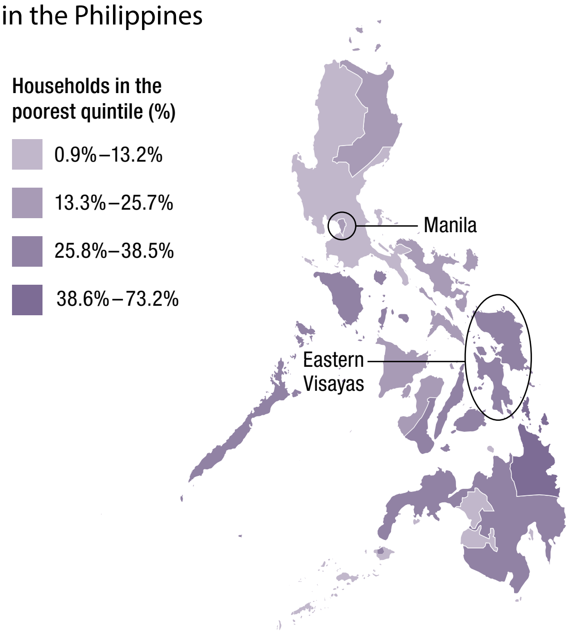
4.3 Looking ahead: Climate change impacts on major cities

Typhoon Haiyan was a wake-up call for the Government of the Philippines. The high death toll and widespread destruction has highlighted the need to improve preparedness and climateproof infrastructure, particularly for the poorest who live in areas with high hazard risk. Commitments to relocate human settlement 40 metres away from the coast, rehabilitate mangroves and retrofit infrastructure are only the first steps to protect the Philippines from future disaster impacts. As Tacloban slowly recovers, discussions about Haiyan's impacts have shifted to how larger cities – including Manila – would cope with an event of similar magnitude (Eadie, 2015). Manila's typhoon risk is ranked as 'high' by the Manila Observatory and the DENR, which is worrying for the city that functions as the engine of the Filipino economy (Center for Environmental Geomatics, 2005). A disaster in the Manila Bay could have profound impacts on national growth and poverty; over 60% of the country's economic growth occurs in the Filipino capital, but it is also home to some of the country's most profound poverty and inequality (USAID, 2014). With its large concentration of slums, heavy traffic, dense population and low-lying geography, Manila is particularly vulnerable to floods and cyclones and any rise in sea level will intensify their impact. However, it is important to consider local configurations of exposure (including topography, along with the location and quality of housing and critical infrastructure) and poverty, as these will determine the impacts of future storm surge and flooding more than the characteristics of the storm itself.

Metro Manila has a population of over 20 million, making it nearly 100 times bigger than Tacloban (World Bank, 2010). The 16 cities that comprise Metro Manila are highly vulnerable to disasters due to their lack of transportation infrastructure, percentage of unemployed and uninsured residents, and intensity of land use (Shaw et al., 2010). A typhoon similar to Haiyan could have catastrophic consequences in the capital, particularly for dispossessed populations living in slums where population density is as high as 75,000–80,000 people per square mile (Roy, 2014). Indeed, poverty maps indicate similar concentrations of poor households in Manila and Eastern Visayas – where Haiyan first made landfall – in terms of the proportion of households in the poorest quintile (see figure 9). Furthermore, most of Manila's poor families live in areas facing Manila Bay. Recent statistics estimate that 15% of households in the metropolitan area live in informal housing, a figure that reaches nearly 40% in some of the poorest sub-cities within Metro Manila (ICF International, 2014) (see figure 10). The proliferation of informal settlements has modified natural flood drainage channels by increasing built surfaces and filling channels with debris, making these already precarious settlements even more vulnerable to heavy rainfall. These informal settlements have become a persistent phenomenon in many parts of Metro Manila, moving further into hazard-prone areas and entrenching patterns of exposure to cyclones, storm surge and flooding as in-migration intensifies.

Informal settlements can be found all over Metro Manila, although those that are among the most exposed to flooding and storms are also in municipalities with high percentage of family incomes below the national poverty threshold (a high poverty gap) (see figure 10). For example, Malabon City, situated just north of the City of Manila, has a high poverty incidence and a large poverty gap, and is also among the areas most vulnerable to sea level rise, flooding and typhoons. It is known as Little Venice for the year-round flood along its river bank. Despite Malabon's gradual sinking, informal settlements along the river bank continue proliferating, housing those who want to live in Manila but are unable

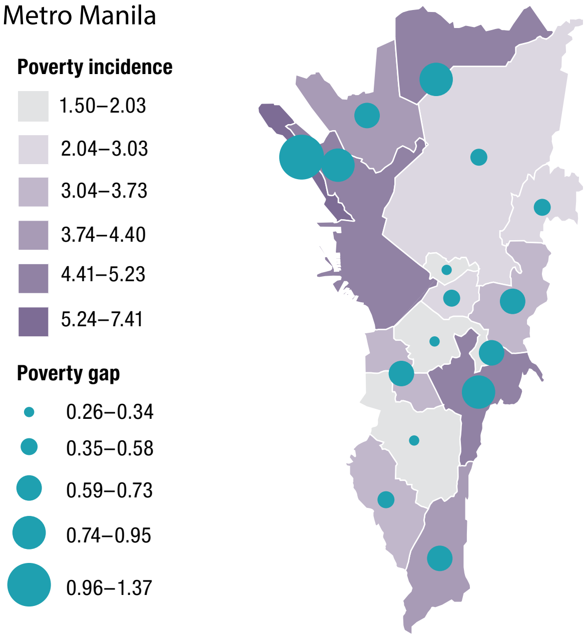
Figure 9. Regional distribution of poorest households in the Philippines



The share of households in the poorest quintile in the Philippines. Metro Manila, located in the northwest of the country, has a similar poverty profile to the Eastern Visayas, where Haiyan first made landfall.

Source: Author calculation based on data from Demographic Health Survey (2013)

Figure 10. The incidence of poverty and poverty gap in Metro Manila



Poverty incidence is the percentage of population in poverty. Poverty gap is the percentage of the amount of the shortfall of incomes in relation to the poverty line.

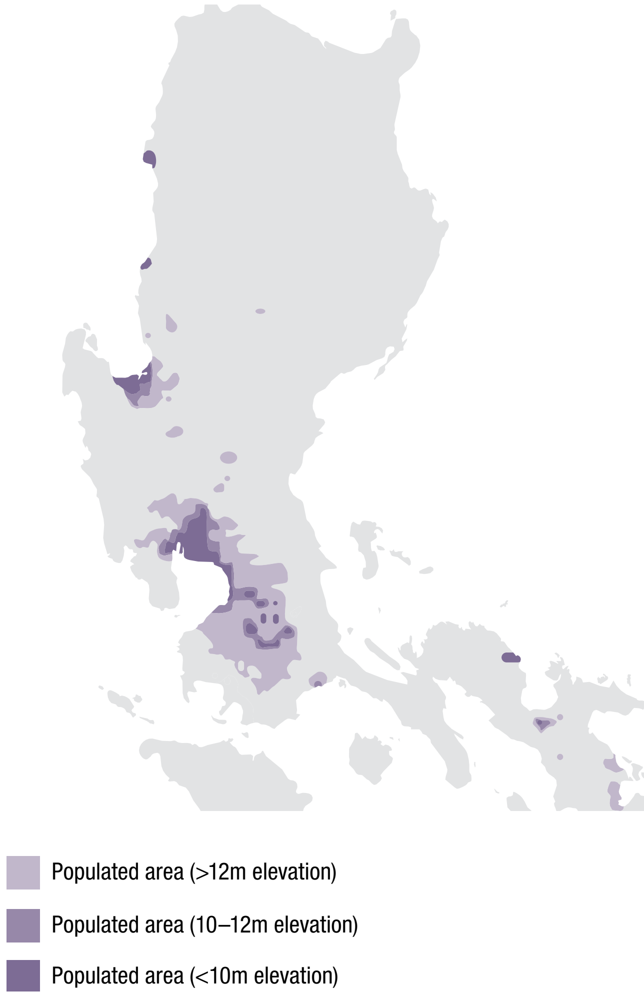
Source: Nakamura (2009)

to afford property in safer parts of the city. For families who live along the river, regular downpours and typhoons force them to evacuate to designated centres until the water recedes. Directly adjacent to Malabon is Navotas City, which has one of the highest incidences of informal settlements in Metro Manila, with nearly 40% of households living in informal settlements in 2002. It also has one of the highest levels of poverty. This is unsurprising because informal settlements arise partly due to a lack of affordable accommodation available on the formal market and in safer locations. Navotas City is situated directly on the bay, making it highly exposed to storm surges. This combination of exposure, poverty and informal housing makes Navotas city extremely vulnerable to cyclones. This risk is real: over 15% of typhoons crossing the Philippines pass by Manila and its vicinity (World Bank, 2010).

Rising sea levels pose a serious threat to Metro Manila, although there is considerable uncertainty regarding the specific level of change

Storm surge, rather than storm intensity, was responsible for most of the Haiyan casualties in Tacloban. Models of storm surge using the Regional Ocean Modeling System (ROMS) show that if a category 3 typhoon were to pass over Manila on a track similar to Typhoon Angela in 1995, Manila City would experience approximately 1 metre of storm surge from Manila Bay (Drews and Han, 2009). This would affect Navotas and Malabon, and huge agglomerations of informal settlements would be severely damaged (Nakamura, 2009; Drews and Han, 2009). This is corroborated by a study of storm surge sensitivity, which ranks Manila first of 25 cities in terms of population that will be affected by storm surge in the future (Dasgupta et al., 2009). Rising sea levels pose a serious threat to Metro Manila, although there is considerable uncertainty – particularly at the regional level – regarding the specific level of change. At the global scale, sea levels are projected to increase by between 57 and 110 cm by the end of the 21st century (Jevrejeva et al., 2014). As an indication of the changing exposure to storm surge, figure 11 highlights densely populated areas (over 1000 people per kilometre^2) that are less than both 10 and 12 metres above mean sea level. The 10-metre threshold shows populations sensitive to a storm surge of between 7 and 8 metres (although precise impact depends on local characteristics and topography) (Lin and Emanuel, 2015). The 12-metre threshold illustrates areas that will be potentially at risk as sea levels rise over the coming years. Over Metro Manila, a 2 metre sea level rise would mean a large expansion of the potentially affected area. At the national scale, given the large number of people living in areas at low elevation, this would increase the proportion of the population potentially exposed from approximately 17% to 22%.[3]

Figure 11. Densely populated areas (>1000 people per km^2) less than 12 and 10 metres above mean sea level respectively for the northern Philippines



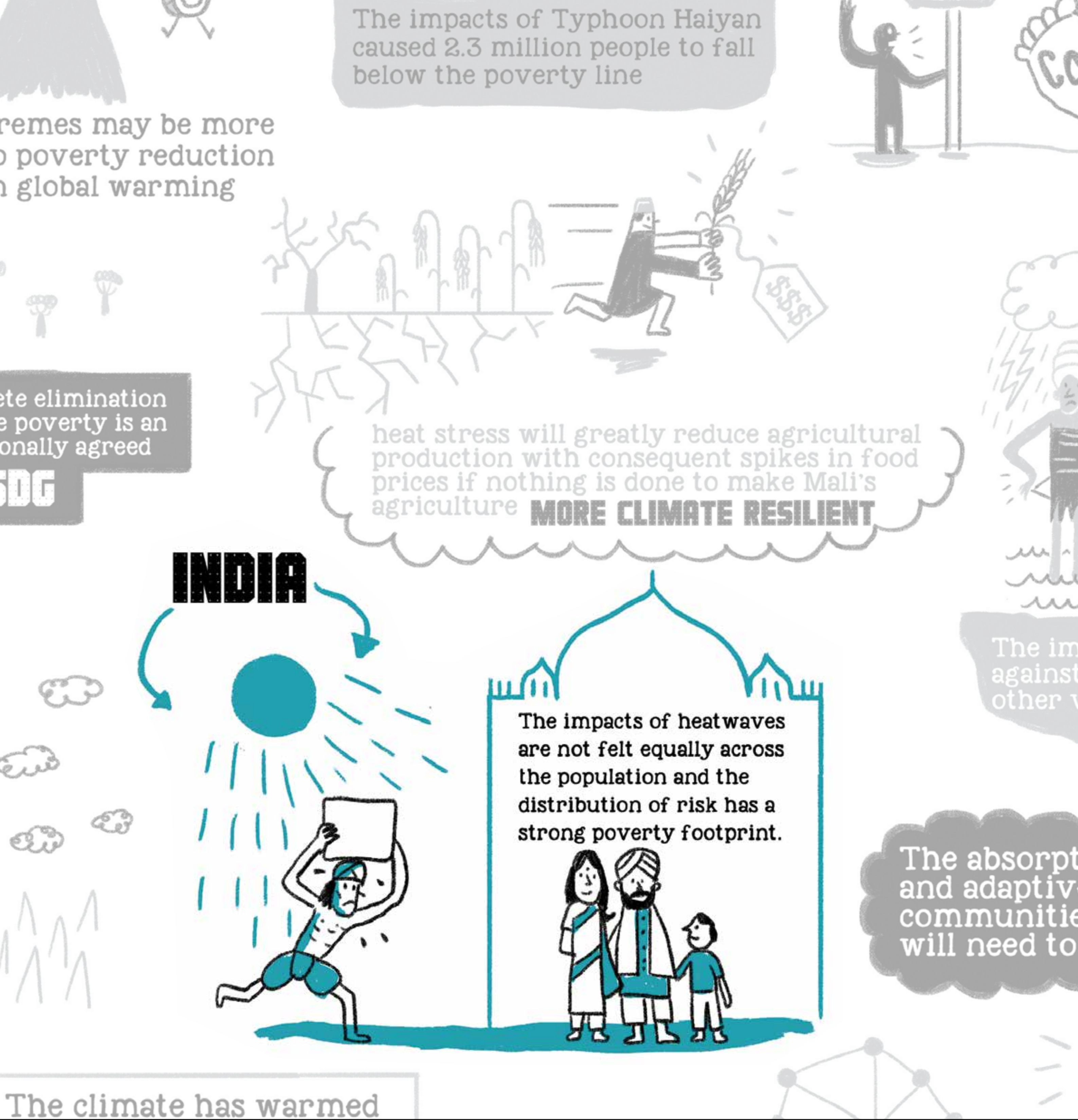
Source: Fischer et al. (2008), FGGD (2015)

3. Calculated from Food and Agricultural Organisation (FAO) estimation on population density for 2015 and FAO elevation datasets. Difference in total population living 0–10 m above sea level and population living 0-12 m above sea level. Based on low resolution data and estimation of population density.

The low-lying geography of Manila's littoral, along with its most densely populated areas being in locations of less than 10 metres above sea level, means sea level rise will undoubtedly have serious consequences for its inhabitants. An Asian Development Bank study has ranked the Philippines fifth in terms of numbers of individuals potentially affected by sea level rise (ADB, 2012). Worse yet, groundwater pumping in some parts of Manila, such as Navotas, is causing land to sink. This is producing tides that reach further inland and causing floods that rise faster, which can be devastating for houses situated around drainage pathways (World Bank, 2010). Exposure to storm surge and flooding is not simply a matter of elevation; local characteristics in these slums define how heavily they will be affected.

The Philippines already receives more than its fair share of disasters but, with rising sea levels and potential increases in tropical cyclone intensity, development gains will be further jeopardised without policies to protect the most vulnerable. The 40 m no-dwell zone declared after Haiyan is an illustration of how this might be enacted. However, experience also shows that for such a measure to work, simultaneous livelihood support for populations that depend on access to the coast will be required.

Strengthening of local DRM institutions combined with considerable investments in early warning systems and preparedness for cyclones, has substantially increased the capacity of communities in the Philippines to anticipate 'normal' climate extremes and cope with these shocks. However, extreme events like Haiyan severely test local coping capacities and these types of events look set to become more frequent. In the Philippines, the whole population lives within 100 kilometres of the coast and many major cities – including four with a population of over a million – are situated in coastal areas. Solutions are needed to strengthen the adaptive capacity of those that are most vulnerable. Uncertainty is the 'new normal', and building resilience to future storm surge and cyclonic activity requires investments in DRM that are sensitive to the needs of the poorest people, particularly those living in informal housing in coastal cities. Cyclones are a geographic reality, but disasters can be avoided. In the Philippines, inclusive development must support the capacities of coastal populations to face future risks.



CHAPTER 5

Poverty impacts of heatwaves in India

Summary

Heatwaves are often overlooked as disaster events, but they can be dangerous, even deadly. There is a widespread lack of awareness of the symptoms of heat stress, as well as the measures that can be taken to reduce risks. In India, heatwaves are common throughout the pre-monsoon hot season, particularly in the northern states that are home to many of the country's poorest people. Climate models suggest there will be an increase in the number of heatwave days across much more of Northern and Central India in the future. Heatwaves in May 2015 affected a large part of the country and claimed the lives of more than 2,300 people, with temperatures 5.5°C above average for nearly two weeks.

- The impacts of heatwaves are not felt equally across the population. In India, the worst affected are people who are poor, elderly or homeless, along with residents of urban slums and those who work outdoors, such as construction workers, rickshaw pullers or street cleaners.
- Some Indian authorities are beginning to recognise and address the impacts of heatwaves. Odisha state, for example, developed a heat plan to build anticipatory capacity; more recently Ahmedabad city has established a Heat Action Plan with a comprehensive strategy for reducing the impacts of extreme heat.
- Climate projections suggest increased frequency and intensity of heatwave days by the middle of the century. At the same time, numbers of Indians living in cities and that are vulnerable to heat stress is increasing.
- It is unclear to what extent those that are most vulnerable are benefitting from current efforts to build resilience.
- An important factor hindering progress is the national government's failure to recognise heatwaves as disaster events. Officially listing heatwaves as disasters would be a welcome first step in building resilience.

5.1 The heat threat

Around the world, heat extremes and heatwaves are on the rise (Smith et al., 2013; Perkins et al., 2012; Alexander et al., 2006). The number of extreme hot days has been steadily increasing across most of the world in recent decades, with 2014 now currently the hottest year on record (Seneviratne et al., 2014; Trenberth, 2015). This trend looks set to continue, with climate model projections suggesting extreme heat increases are likely across most of the planet in the years to come (Sillmann et al., 2013).

Heatwaves are dangerous because of the body's sensitivity to temperature. The body needs to maintain a core temperature of approximately 37°C in order to function, so mortality and impacts on health are the most significant heat-related risks; sustained exposure to heat can overwhelm the body's mechanisms to regulate this core temperature. As perspiration is the primary cooling mechanism, early signs of heat stress include heavy sweating, along with rapid breathing and a fast, weak pulse. If the body loses the ability to perspire or the effectiveness of perspiration is limited by high humidity, heat stress can quickly lead to heat exhaustion, severe dehydration and heat stroke, a form of hyperthermia. Symptoms vary, but can include headaches, dry skin, vomiting, dizziness and low blood pressure. These heat impacts become deadly when the body's core temperature rises too high and the heart is no longer able to maintain adequate circulation, leading to unconsciousness and ultimately organ failure (Bouchama and Knochel, 2002).

To a large extent, heat-related mortality and illness are preventable and can be treated through cooling and rehydration. However, there is a widespread lack of awareness of the symptoms of heat stress and the measures that can be taken to reduce risks. There are cases reported in the media, for example, of families and health workers mistaking the symptoms of heat stroke for stomach problems (Sriram, 2015). As a result, heatwave fatalities tend to be underreported, particularly in developing countries (Thompson, 2015), meaning data on heat-related illness is especially limited.

While the most significant threat from extreme heat is to human health, this can also have knock-on effects on the local and national economy. Heat stress is known to reduce productivity when places of work are forced to temporarily close or when people are too unwell or tired to work (Zander et al., 2015). Heatwaves can also have direct impacts on temperature-sensitive sectors, such as livestock and agriculture. During a recent heatwave in India, 17 million chickens died within a month, which not only had implications for the poultry sector and corn producers, but also caused the cost of chicken to jump by 35% (Jadhav, 2015).

Evidence of the broader impacts of heatwaves on development is relatively limited, compared to other hazards, but examples are emerging from the region. In Pakistan, for instance, heat stress has been shown to drive rural-urban migration, as heat-related crop damage reduces farmers' incomes (Mueller et al., 2014). Heat events appear to be a bigger driver of migration than floods in Pakistan, with farmers – especially men who do not own the land they are farming – moving to urban centres in search of economic stability (Mueller et al., 2014). It seems likely that a similar story plays out in heat-affected parts of rural India.

5.2 Heatwaves in India

In India, heatwaves are common throughout the pre-monsoon hot season, from late May and into June; in rare cases these extend into July, particularly in the north west (De et al., 2005). In recent decades, significant heat-wave events have occurred in 1995, 1998, 2002, 2003, 2010, 2011, 2013 and, most recently, in May 2015 (Jha et al., 2015). However, these events are not spread equally either across the country or year-on-year: some hot seasons are notably warmer than others and the north of the country tends to suffer more intense, longer-lasting and regular heatwaves than the south (De et al., 2005). As shown in figure 13 the hottest temperatures tend to occur along the border with Pakistan, but long-lasting heatwaves are experienced across much of northern India (Murari et al., 2015). Historically, the northern Indian states of Uttar Pradesh, Punjab, Madhya Pradesh, Gujarat, Rajasthan, Bihar and Odisha (formerly Orissa) record the highest numbers of heatwaves and heat-related deaths (De and Sinha Ray, 2000). These northern states are also home to many of India's poorest people and are also sites of some of the country's most rapid population growth.

5.2.1 India heatwave 1998

The heatwave of 1998 was the deadliest event of its kind in India's recorded history, claiming the lives of 2,541 people, with the east coast state of Odisha being the worst hit. Temperatures peaked at 48.9°C in Titilagarh in Western Odisha, while towards the more humid eastern coast, the state capital Bhubaneswar experienced highs of 45.9°C (The Hindu, 2000). Odisha has a long history of cyclones, flooding and drought, but a heatwave of such severity was unprecedented and took the public and the authorities by surprise (SANDEE, 2012), leading to 2,042 people losing their lives. It is thought that lack of preparedness prior to this event was largely due to low levels of awareness of the risks associated with heatwaves or the options for mitigating these impacts (Das and Smith, 2012).

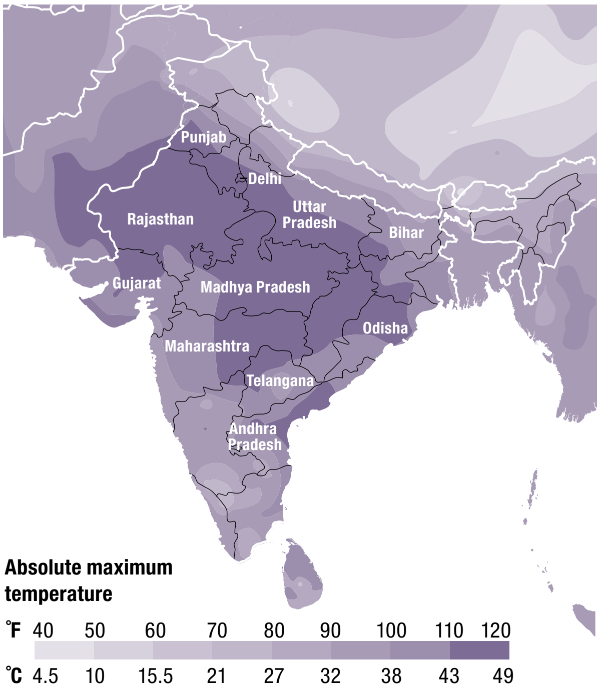
5.2.2 India heatwave 2015

The heatwave of 2015 is significant as India's second deadliest heat event. Estimates indicate that the hot weather claimed the lives of more than 2,300 people across the country in May 2015 (Jha et al., 2015). A very rapid rise to heatwave temperatures likely played a role in the sale of the impact.

Heatwave conditions affected a large part of India, with temperatures 5.5°C above average for nearly two weeks (Samenow, 2015). Lives were lost in Odisha, Uttar Pradesh, Delhi and other North Indian states and cities, as daytime temperatures regularly exceeded 40°C (see Figure 12). In some coastal areas the combination of high temperatures and high humidity added to the heat risk (Thompson, 2015). However, the impacts were felt most in Andhra Pradesh and Telangana, further south than for past events, claiming the lives of 1,636 and 561 people respectively in these two states (Tuff, 2015). Temperatures here rapidly soared to the high forties during the day and remained at around 30°C overnight; such persistently high temperatures can have more of an impact on residents because of the lack of relief (Thompson, 2015). India was not the only South Asian country affected by heatwaves in 2015; in June, Karachi and adjoining areas of Sindh in neighbouring Pakistan also recorded upward of 2,000 heat-related deaths (Haider and Ani, 2015).

Throughout the 21st century temperatures are projected to significantly increase across the region (IPCC, 2014a). For the mid-21st century period, under a "business as usual" greenhouse gas scenario, there is a clear signal from climate models for slight increases in the intensity of heatwaves, but large increases in the number of "heatwave" days (Figure 13). A relatively small increase in average temperatures can result in a large increase in time above certain thresholds. For example, initial analysis of climate models suggest pre-monsoon season heatwave conditions could become almost twice as frequent in the North West regions of India, and almost three times as frequent in the central regions by the 2050s. Individual models (Murari et al., 2015) also project increases in both the intensity and frequency of heatwave conditions in the

Figure 12. Daytime maximum temperature during the week May 24–30, 2015



Source: NOAA (2015)

southern regions, which are historically less prone to these events. The recent 2015 heat event in Andhra Pradesh and Telangana may therefore be a sign of things to come for historically less affected southern India.

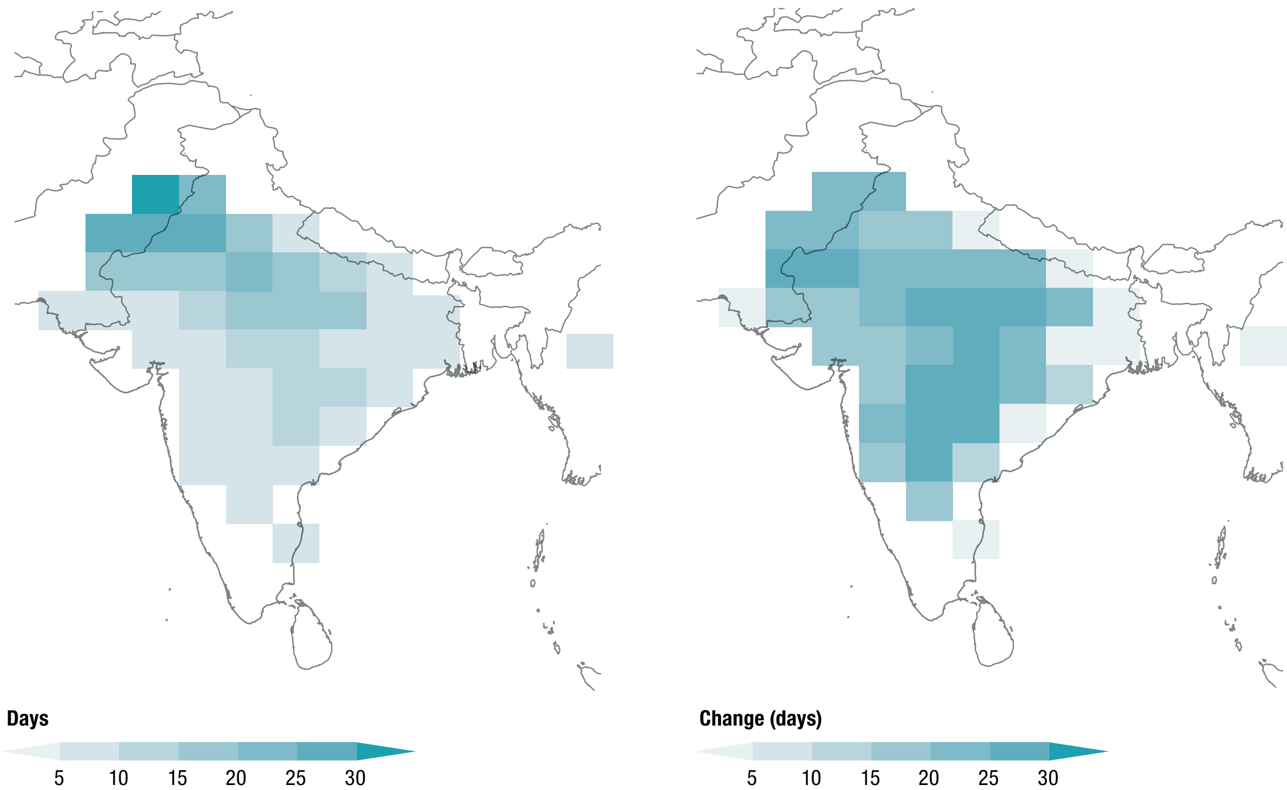
5.3 Distributional impacts of heatwaves

The impacts of heatwaves are not felt equally across the population and factors that increase vulnerability to extreme heat include:

- old age and underlying health conditions such as cardiovascular diseases, psychiatric and pulmonary illness
- low mobility and confinement to a bed
- social isolation
- physical exertion in hot conditions
- poor quality housing
- living in an area with high population density
- limited vegetation and open space
- restricted access to clean water and electricity

(Milan and Creutzig, 2015).

Figure 13. Average number of pre-monsoon "heat wave days", 1981–2010 (left) and change by the mid-21st century under a business as usual greenhouse gas scenario (right)



Due to the urban heat island effect, risks are often highest in urban areas and many of the factors above are closely linked to poverty. In addition to the higher temperatures often experienced in urban areas, heat stress and associated health impacts can also be compounded by poor air quality, which typically occurs under the same weather conditions that produce extreme urban heat (Wilby, 2008).

The urban population in India has been growing steadily and UN projections have estimated this will rise from 31% in 2011 to approximately 40% in 2030 adding another 225 million people to urban areas, more than the population of Japan and Germany combined. Those moving from rural to urban areas are particularly vulnerable to heatwaves because they are generally poor. Most will move to densely populated areas, and have poor quality housing with restricted access to clean water and electricity. They will also be less connected to support networks and services than established city dwellers. In addition, the UK Government Foresight Report found that when people's incomes are threatened by environmental change they migrate in 'illegal, irregular, unsafe, exploited or unplanned ways'. As a result, they are also more likely to find themselves migrating to areas of high environmental risk, such as low-lying ureas in mega-deltas or slums in water-
insecure, expanding cities (Government Office for Science, 2011: 104).

Across India, the worst affected by heatwaves are poor, homeless or elderly people, along with residents of urban slums and those who work outdoors, such as construction workers, rickshaw pullers or street cleaners. These groups endure greater exposure to the heat and tend to have less access to air conditioning, refrigeration, clean drinking water, healthcare or other resources that mitigate the effects of heat (Thompson, 2015). Many of India's poorest are daily wage earners, which adds to their vulnerability, because they cannot stop working when temperatures creep up to dangerous levels; conversely, people who are unable to work due to heat-related illness lose vital income.

Epidemiological studies suggest that risks for men and women do not differ significantly (Tan, 2008). However, evidence from Pakistan indicates differences in the causes of men and women's vulnerability. Women often face continuous exposure to the heat in poorly ventilated homes and, unlike men, are unable to sleep outside on roofs to escape high night-time temperatures, while men working in construction or other outdoor labour face greater exposure to peak daytime temperatures (Khan et al., 2014). Traditional gender roles in India may play a role in shaping these vulnerabilities.

5.4 Building resilience to heatwaves

The imagery of heat stress is less powerful when compared to the crashing waters of a flood or the lashing winds of a cyclone, with the visible devastation such events leave behind. With heatwaves, impacts are more difficult to visualise and this goes some way to explaining the limited attention given in the media and lesser efforts to build resilience to extreme heat.

In India, efforts to tackle extreme heat have been led from the subnational level, rather than by central authorities. Odisha was the first state in India to recognise and address the impacts of heatwaves following the devastating heatwave of 1998 and cyclone of 1999. The state established the Odisha State Disaster Management Authority in 2000 and a heat plan was developed in 2002 as part of the Disaster Management Plan (Jha et al., 2015). The state government worked closely with lower levels of government to implement the plan and heatwave risks have continued to feature prominently in Odisha's subsequent Disaster Management Plans. The heat plan focuses on building anticipatory capacity: it is centred around an early warning system and heat awareness campaign, focusing on bringing about behavioural changes that reduce vulnerability. Heatwave alerts from the Indian Meteorological Department are monitored during the pre-monsoon summer months and tips for how to cope with heatwaves are shared through the media, local volunteers and health workers, amongst others (SANDEE, 2012). Health services and other relevant departments are required to be prepared to enact emergency measures (OSDMA, 2013). These include arrangements for emergency drinking water supply; rescheduling school days and working hours, especially for those employed in outdoor, physical labour; and veterinary measures to protect livestock (OSDMA, 2013).

Taking this effort a step further, the city of Ahmedabad in the north western state of Gujarat has also begun to tackle heat impacts. As in Odisha, action in Ahmedabad was prompted by a severe heatwave. Research indicates that a major heat event in 2010 killed an estimated 1,344 people, many more than the 50 deaths reported by city officials at the time (Azhar et al., 2014) or the 250 heatwave deaths recorded for India as a whole that year (Guha-Sapir et al., n.d.). This served as a wake-up call for local authorities and prompted coordinated action to ensure the city and its residents were better prepared for the next such event. From

2012, city authorities worked with partners to establish a Heat Action Plan. Launched in 2013, it is the first of its kind in South Asia.

The Heat Action Plan sets out a comprehensive strategy for combatting extreme heat in the city of Ahmedabad, including short- and long-term actions to minimise heat-related health risks, along with prioritising actions that can be implemented at low cost with maximum impact (CDKN, 2014). As with the Odisha case, actions to raise awareness and build anticipatory capacity form major components of the plan. This includes a strong emphasis on building institutional capacity to manage and deal with the impact of heat extremes. The strategy requires, for example, the training of healthcare workers and others employed in vulnerable sectors, such as construction, to recognise and treat heat stress. City-level, interagency coordination to manage heat risks and deliver an emergency response effort has also been established. Measures to reduce the heat threat from the built environment under hot conditions have also been taken, such as moving the hospital's maternity ward away from the top and hottest floor, painting the hospital roof white, opening 'cooling spaces' in temples and shopping malls, and keeping parks open at night to offer some relief from the heat. India is no stranger to heat and many of these measures will have benefits for vulnerable populations even outside heatwave periods.

In Delhi, the authorities responded to the heatwave in 2015 by halving the price of electricity and increasing the availability of free water in an effort help residents to cope with the heat

Ahmedabad is the only city in India to have enacted such a comprehensive plan to protect its residents against the effects of heatwaves. However, this forward-looking example has prompted other cities and states to think about taking heat risks more seriously. The city of Nagpur in the state of Maharashtra, for example, is reportedly devising its own plan, learning from experience in Ahmedabad (Jha et al., 2015). In the city of Surat in the state of Gujarat, some measures to reduce heat risks such as cool roofs are being rolled out, although no formal action plan has yet been developed (Jha et al., 2015). In Delhi, the authorities responded to the heatwave in 2015 by halving the price of electricity and increasing the availability of free water in an effort help residents to cope with the heat, although demand for electricity soon outstripped supply resulting in widespread power cuts (Roy, 2015).

5.4.1 Are these efforts working?

Evaluating the impact of these efforts is fraught with challenges. Heatwaves are sporadic by nature and differ in their severity and length, making it difficult to compare their impacts even if they occur in the same year (Indian Institute of Public health, 2014). Equally, as heat-related health issues are often misdiagnosed, records of heat-related illness and mortality are inconsistent (Indian Institute of Public health, 2014). International precedents to guide impact assessment are rare.

Although the evidence is still patchy, there are signs that efforts to strengthen the anticipatory capacity of local systems have helped to reduce the impacts of extreme heat. In Odisha, measures implemented after the 1998 heatwave seem to have led to a decrease in heat-related mortality. Heatwave deaths in this state have only once exceeded 100 per year since 1998, when an extreme 2005 heatwave, with temperatures 10°C above normal, led to 236 deaths (SANDEE, 2012). In Ahmedabad, an evaluation of the first two years of the Heat Action Plan points to a decrease in excess heat-related mortality of 24% in the hottest months of 2013 and 2014, although the heat seasons in both these years were less severe than in 2010 (Indian Institute of Public health, 2014). However, even in the relatively well-documented Odisha case, a lack of data means tracking progress on reducing impacts other than mortality – such as reduced heat-related hospitalisations, or work-time loss – is challenging (SANDEE, 2012). In addition, it is not clear if these measures are reaching the most vulnerable. Many workers on daily wages are unable to follow advice to change their working hours or stay in the shade and household incomes often drop due to decreases in productivity, just at the time when personal spending on healthcare and recommended foods, such as fruit, is needed. A third of India's population does not have access to electricity, meaning many of Delhi's residents, for example, have been unable to benefit from the cheaper price of air conditioning provided by the city's 2015 electricity price cuts (Roy, 2015). However, measures such as the provision of free water and cooling spaces are designed specifically for vulnerable groups, and the effectiveness of these needs to be evaluated.

5.5 The way forward: mobilising action

To date, action to increase resilience to heatwaves in India has taken place at the subnational level and only in cities and states that have recently suffered human losses. India's federal structure and various acts of political, administrative and fiscal devolution mean much of the responsibility for managing disaster risk lies at the subnational level. While actions described in this report are positive, efforts to tackle heat risks are currently piecemeal, with most Indian cities and states ill-prepared to cope with heatwaves (Gupta, 2015). Inconsistency at the subnational level leaves vulnerable groups in most Indian states at unnecessary risk.

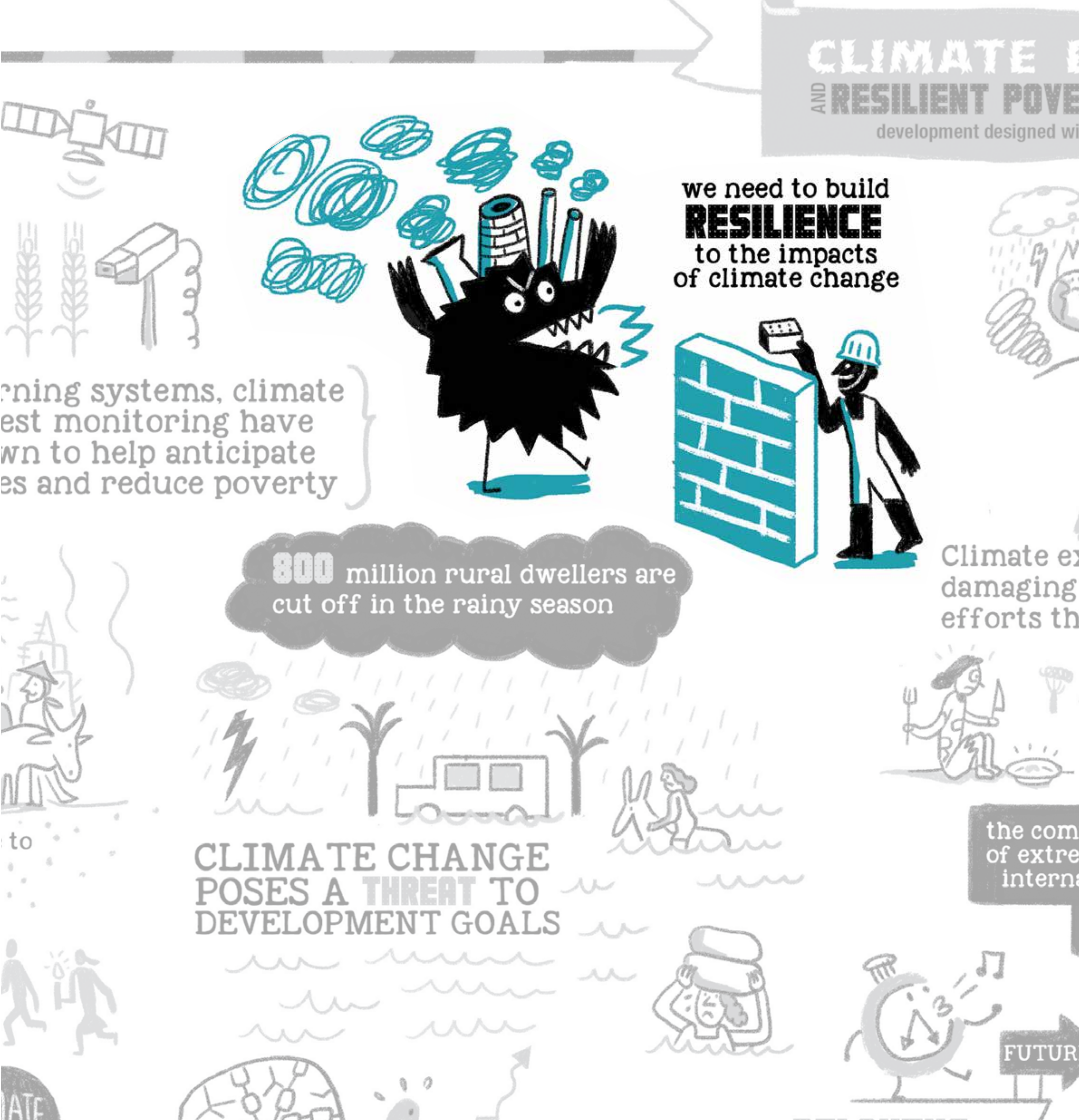
This inconsistency also plays out at the global scale. A handful of countries such as France and the UK have national-level heatwave plans, but elsewhere such systems are uncommon (DAWN, 2015). The World Meteorological Organization and the World Health Organization have recognised that heatwaves are a dangerous climate extreme not receiving enough attention and, in July 2015, released joint guidance on heat-health warning systems to address the risks posed by them (WMO and WHO, 2015).

In India, one important factor hindering progress is national-level authorities' lack of recognition of heatwaves as disaster events (Gupta, 2015). Unlike cyclones, droughts, earthquakes, fires, floods, cold waves and hailstorms, heatwaves do not qualify as disasters under India's Calamity Relief Fund and National Calamity Contingency Fund (India Disaster Knowledge Network, 2009), despite requests for their inclusion by the Odisha State government and the National Disaster Management Authority (OSDMA, 2013). This sends a counter-productive message to state governments regarding the need to tackle heat risks. In addition, it carries financial implications; subnational authorities are unable to access these funds for heat-risk reduction efforts or to provide financial relief for bereaved families (OSDMA, 2013).

A step forward in recognising the threat from heat at the national level may soon come as part of India's strategy for adapting to climate change. India's Intended Nationally Determined Contribution (INDC), submitted to the UNFCCC ahead of the 2015 Conference of the Parties (COP21), acknowledges increased frequency of heatwaves alongside other health risks associated with climate change and weather-related disasters. The country is now formulating a 'Health Mission' as part of the National Action Plan on Climate Change (NAPCC), which will analyse epidemiological data, identify vulnerable populations and regions, and build knowledge, expertise and awareness (UNFCC, 2015). The INDC also acknowledges the important link between adaptation and disaster risk reduction. However, while strengthening the connection between policy and planning across these areas would be beneficial, no roadmap for achieving this has been laid out.

India's urban centres and urban slums are rapidly expanding and climate change is driving temperature increases across much of the country. Heat risks are therefore on the rise in India, both in areas already prone to heatwaves and in the historically less-affected south. The intensity of hot seasons in specific years to come, along with the locations to experience the most intense and long-lasting heatwaves in any given year, cannot be predicted any earlier than seasonal weather forecasts allow. Therefore, it is imperative that efforts to build resilience to extreme heat, alongside other hazards, are systematically made across the country, targeting the most vulnerable.

An official listing of heatwaves as disasters by the national level authorities would be a welcome first step in realising heatwave resilience. This would help provide subnational authorities and relevant national agencies, such as the Indian Meteorological Department, with a mandate and resource to take appropriate action, according to their respective responsibilities and budgets (Johari, 2015). As urban areas expand, there is an opportunity to embed resilience to heatwaves, through urban planning and building design; a supportive policy environment would help ensure this opportunity becomes reality. Given experience in Ahmedabad and elsewhere, there are significant opportunities for horizontal lesson-learning on effective strategies for tackling extreme heat in the Indian context, alongside other urban threats. By following Ahmedabad's example, and with support from the national-level systems, cities and states across India could make significant headway in enhancing resilience to extreme heat.



CHAPTER 6

Resilience solutions for an uncertain future

Summary

This chapter discusses principles, and planning and policy tools, for building resilience in the face of uncertainty. The challenges of underpinning projections of future climate change and its augmentation of extreme events, along with the development context in which these events will play out, requires new approaches to supporting resilience. Given what we now know about the multiple poverty impacts of disasters, the different scales across which these are felt and the fact that there is no simple co-location of these phenomena, efforts to pursue development and build resilience to climate extremes will need to switch their focus:

- We will need to pay more attention to building capacities of communities and societies to anticipate, absorb and adapt to climate extremes, than on targeting solutions at particular places or types of extreme events that are expected in the future.
- However, iteratively building capacity to anticipate, absorb and adapt to climate extremes may not be sufficient to secure poverty reduction in the face of climate change.
- Planning and policy tools will also need to promote transformative changes to fundamentally and sustainably improve resilience in ways that will often challenge existing socio-economic and political systems.
- Solutions will need to link different institutions that have previously been poorly connected, such as social protection and early warning systems.
- Solutions will also need to prioritise new criteria in decision-making, such as whether they are robust across different possible climate futures and whether they are flexible enough to be easily altered.
- This will enable us to develop solutions that are not focussed on any one particular event, location, or group of people, but can be adapted across different climate scenarios.
- Evidence tells us this is feasible, but that the scale of ambition and action we have achieved to date must rise.

6.1 Principles for building resilience in the face of uncertainty

Climate resilience has multiple meanings, most of which draw heavily on ecology and refer to the ability of systems to function in the face of disturbances (Holling, 1973). DFID defines resilience as the 'ability to anticipate, avoid, plan for, cope with, recover from and adapt to (climate-related) shocks and stresses' (DFID, 2014). For the UN Secretariat for Disaster Reduction, resilience is thought of as 'the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure' (UNISDR, 2009).

When translating definitions into practical action, they all have in common a sense that processes will need to incorporate learning from experience in order to be effective. Resilience building will also necessitate testing and adopting different and innovative ways of working, with a fundamental shift in the scope, coverage, intensity and combination of approaches possibly required. This may involve both the generation of new knowledge and greater recognition of the social, political and economic realities that shape different groups' vulnerabilities to persistent poverty and climate change.

6.1.1 Building adaptive, anticipatory and absorptive capacity – the 3 As

Tackling the combined challenges of poverty eradication and climate change requires action to increase the resilience of communities and societies most vulnerable to increasing climate risks, by strengthening their capacity to anticipate, absorb and adapt (Bahadur et al., 2015;). These three capacities are considered integral to development and necessary to avoid climate risk trajectories severely undermining efforts to reduce poverty. As Bahadur et al. (2015) describe:

Adaptive capacity is the ability of a social system to adapt to multiple, long-term and future climate change risks, and also learn and adjust after a disaster. An example of adaptive capacity is the ability of farmers to diversify their risk profiles by deciding to pursue non-agricultural livelihood activities in sectors that may be less climate-sensitive (e.g. artisanal trades) so that even if one source of livelihood is disrupted, another continues.

Anticipatory capacity is the ability of a system to anticipate and reduce the impact of climate variability and extremes through reduced exposure and vulnerability to specific (known) hazards. Actions that are indicative of anticipatory capacity include a range of emergency preparedness activities, such as training exercises and simulations, contingency preparedness and response planning, and pre-positioning of goods and services.

Absorptive capacity is the ability to absorb and cope with the impacts of climate variability and extremes, through emergency management, to minimise damage and disruption. Having savings and safety nets in place can help buffer disaster impacts, allowing people to recover more quickly. Therefore, having access to micro-credit, weather-indexed insurance and social protection is often seen as a sign of absorptive capacity.

All three capacities are required, though it is only within a specific context that one can determine a) the weight of emphasis required between each and b) which need to be strengthened, depending on the needs and existing capacities of communities, as well as the types of risks faced. For example, the capacity of a country like Japan (see box 2) to anticipate and absorb hazards is not found in many other places and the cost of flood control programmes is beyond the

Box 2. Flood risk management in Japan

Investment in building resilience to cyclones and flooding has had marked results in Japan, in terms of both reducing mortality and damage to property. Japanese data provide some of the best demonstrations of what can be achieved in terms of building resilience to multiple shocks and stresses. Detailed and comprehensive data on disaster deaths, as well as houses damaged and destroyed, have been collected since 1945, when the country was administered by the US.

A major national campaign of disaster risk reduction was instituted in 1961 after a catastrophic storm surge flood in Ise Bay inundated much of the city of Nagoya, leading to more than 5,000 deaths. The 1961 ‘Disaster Countermeasure Basic Act’ legislated a change from a reactive to proactive approach to disasters (National Land Agency Japan, 1961). Regional disaster prevention plans were established, including forecasting systems, flood defences, warning criteria, rescue systems and emergency communications. During the 1960s and 1970s, many multi-purpose dams were built for both flood control and water supply, allied with programmes of river channel capacity expansion and increased retention capacity to mitigate increased run-off from urban development. The government also funded the development of high-resolution flood hazard maps to inform development and land-use decisions.

The demonstration of progress in Japan is most convincing for typhoons. The average annual mortality rate reduced from 1.1 per 100,000 people in the 1950s to 0.08 per 100,000 people in the 1960s. Compared with the 1960s, the 1950s was a period of intense and damaging typhoon activity, so this reduction is not entirely linked to the implementation of Disaster Risk Management policies in 1961. However, the relatively low mortality rate persisted even when typhoon activity picked up again after 1990, highlighting that, in the longer-term, a significant part of this reduction was the product of active intervention: from protective infrastructure through to better preparedness planning and evacuations. For non-typhoon related floods, there was a 66% decrease in mortality from the 1950s to the 1960s, with a further 58% reduction between the 1960s and the 1970s. There is no suggestion of any significant decadal variability in precipitation in Japan, so these reductions do appear to reflect principal improvements in flood defence and other DRM investments.

The Japanese experience highlights the order of magnitude of potential reduction that can be achieved in a rapidly growing economy. Structural flood control measures have also led to a significant decrease in the number of houses inundated (which provides a proxy for normalised economic losses). Over the period 1950-1990, the population of Japan and the number of dwelling units increased by around 55%, so normalising the number of houses flooded according to population could only serve to amplify the reduction.

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means of most developing countries. However, what the Japan case does show, as iterated throughout this report, is that there is a need to combine approaches with improved capacity to adapt to multiple, long-term and future risks. This requires 'softer' measures, such as land-use planning that proactively accommodates conditions that have changed or are about to change. This, in turn, demands acknowledgement that the world is in flux, not only in terms of the climate extremes we will face, but also the development backdrop against which the impacts of those extremes will be most deeply felt.

6.1.2 The need for transformation

Climate-related risks to development progress are growing rapidly due to rising levels of exposure, vulnerability and changing hazard burdens influenced by climate change. As a result, building the 3As resilience capacities incrementally may not be enough to secure poverty reduction in the face of climate extremes. For example, incremental changes to current DRM systems in countries like Mali are unlikely to be enough to ensure resilient poverty reduction over the next 15 to 30 years. The scale and scope of future climate risks identified in Mali, India, the Philippines and beyond will require a transformational shift in the way risk is managed, using climate and weather information and scenarios to inform development planning decisions.

> **Through problem identification and the creation of broad-based support, actions can be taken with strong transformative potential**

Attention is turning to the types of transformative changes that are needed in anticipatory, absorptive and adaptive capacity, and how signs of transformation can be detected and supported. A new narrative linking climate and development is needed, whereby transforming resilience capacities is seen as an opportunity and impetus for change and progress toward poverty reduction and economic growth. "Transformation refers to the likelihood of human systems to fundamentally and sustainably improve the resilience of vulnerable citizens to the impacts of climate extremes and change" (Bahadur et al., 2015). As such, this entails enhancing resilience in ways that will often challenge the existing socio-economic and political systems.

Transformational changes tend to be catalytic, leveraging change beyond the initial direct activities; achieve change at scale in terms of outcomes achieved in relation to the magnitude of resource inputs; and are sustainable, insomuch as processes of resilience building are sustained once initial support ends (Bahadur et al., 2015).

Under these criteria, the reform of the Japanese flood risk management system would be classified as transformational, initiating a nation-wide process of risk assessment, infrastructure projects, early warning systems and preparedness planning that continues to be updated and improved on today. This exemplary case may be difficult to replicate because of the high cost, skills requirements and strength of private sector engagement. However, through problem identification and the creation of broad-based support (engaging actors domestically and internationally, including the private sector) actions can be taken with strong transformative potential.

6.2 Planning and policies for building resilience in the face of uncertainty

The uncertainty created by a changing climate and dynamic development trajectories poses challenges for actors' planning and decision-making, many of whom are already trailing new approaches. For example,there is already momentum in a shift toward more robust and adaptive approaches to planning and decision making from fields including climate change (Jones et al., 2014), food security (Vervoort, 2014) and development (Doing Development Differently, 2014). Scenario planning, use of 'serious games' that allow people to explore potential futures and other innovative techniques have been trialled with considerable success, but these pilots now need to be brought to scale and become new standards in planning practice. Solutions need to be designed with uncertainty in mind, starting not with predictions, but plans to reduce poverty in places and within groups already adversely affected by climate extremes and variability. We need to start with the plans and then identify the climate futures most relevant to their success (Lempert, 2015).

This section identifies where planners and policy makers can focus their efforts to improve resilience under uncertainty, drawing on lessons from experience.

6.2.1 Building capacities and strengthening systems

The case studies described in this report confirm there are approaches to building resilience that are making a difference in many communities, but progress has been uneven. Evidence from past events reveal how the influence of climate extremes on patterns of poverty is shaped by capacity at the local and sub-national levels. This is shown clearly through the positive examples of decentralised DRM structures in the Philippines and the network involved in the Mali Météo agrometeorological initiative, where well-connected local structures house significant capacity to strengthen anticipatory action in the face of forecast climate extremes. Initiatives such as these (and the use of Heat Action Plans in India) have worked well at the sub-national level but struggled to be scaled out comprehensively; in some cases, they have seen only partial implementation, due to piecemeal or poorly coordinated approaches.

These challenges point to the continued need for investment in sub-national and local capacities and institutions, and for efforts to strengthen whole systems, such as for drought forecasting and preparedness in Mali (see box 3). Investments in climate services, for example, will need to be accompanied by systemic capacity development to be effective.

In the Sahel, integrating market information in early warning systems at the national and regional levels provides a useful entry point for improving coordination of drought management across these scales (Brunelin, 2015). Meanwhile, the community-based DRM approach in the Philippines, which is strongly rooted in principles of participation and public accountability, has produced a fundamental shift in preparedness and response planning. Building adaptive capacity and avoid increasing exposure to these ever more frequent events will, however, require deeper engagement with the private sector to develop a set of incentives to enhance compliance with the 2013 regulation prohibiting construction within 40m of the coast.

In India, on the other hand, the Heat Action Plan in Ahmedabad and the State of Orissa represent comprehensive strategies for combatting extreme heat at corresponding levels, involving planners, the construction sector, hospitals, schools and other sectors and stakeholder groups. System-wide changes were brought about through concerted action across a range of disciplines and practice areas, including architectural design, training programmes and changes in the use of public facilities. The challenge now is to replicate these experiences so that other states and cities can be better prepared, without having to learn these lessons the hard way. This will require better integration of government

Box 3. Contrasting decentralised drought preparedness in Mali and Kenya

Even when the need to invest in capacity at the sub-national level is acknowledged, decentralised systems often lack frontline resources. They are also frequently poorly connected to other institutions and systems that may be vital to them efficiently responding to extreme climate events. Often organised sectorally, they can also lack a mandate for dealing with complex issues like drought management.

Government in Mali, for example, has been decentralised since the late 1990s; communes have responsibilities in education, sanitation, waste and natural resource management, but are not involved in anticipating or responding to drought. This illustrates a structural deficit that renders these sectors unprotected from drought risk at precisely the administrative level where coordinated action to reduce climate-related risks could be most effective. These authorities could become important entities for resilience building and drought management, helping transmit climate information both upwards and downwards, and contributing to the targeting of vulnerable populations.

Much as the National Drought Management Agency in Kenya houses regional agencies in all counties in the arid and semi-arid regions of the country, the Malian system could rely on a strong decentralised governance structure to extend its drought management and food crisis management systems. If such a system was efficiently harnessed and supported with sufficient human and financial resources, it would help in the coordination of drought management across the different scales of governance. Another advantage to designating and funding a climate risk management mandate at the equivalent of the county (cercle) level in Mali would be that it would increase the efficiency of resilience building across impacted sectors and also link regions that are not equally exposed to drought events but are, as highlighted earlier, nevertheless economically vulnerable to the consequences.

Box 4. Adaptive social protection

One example of a measure designed with uncertainty in mind is adaptive social protection (ASP). At present, despite the known benefits of disaster risk reduction and preparedness, social protection programmes are rarely designed to address the risks and impacts of natural hazards in advance. In most cases, the use of social protection mechanisms to support people to deal with disasters and climate shocks has been ex-post and ad-hoc. However, ASP measures – while still fairly new – offer significant potential to support resilience in the light of increased uncertainty.

The concept of 'adaptive social protection' (ASP) recognises the importance of reducing vulnerability to shocks in the interest of sustainable development and therefore aims to promote integration between social protection, climate change adaptation and DRM. By integrating climate adaptation, social protection could better serve the needs of the poorest and most vulnerable members of society to deal with climate variability and extreme weather events. Meanwhile, DRM and climate change adaptation initiatives could benefit from social protection's mechanisms for lifting the these groups out of poverty. The timeliness and scalability of social protection interventions are central to their effectiveness in responding to disasters and climate extremes, when assistance is needed quickly by large numbers of affected people. To improve these, a growing number of social protection programmes are using triggers such as weather-based indices as features of their design (Bastagli and Harman, 2015).

Innovative cases of adaptive social protection include those with rainfall insurance and temporary employment in community-based DRM projects.

- In Mexico, the Temporary Employment Programme, Programa de Empleo Temporal (PET), includes programmes that build environmental or sustainable agricultural improvements, targeted at community-based projects that reduce risks from climate-related shocks.
- Bangladesh's Chars Livelihoods Programme combines public works that reduce flood risk with post-disaster support to restore assets in the case of a disaster. Its monitoring and evaluation systems measure climate resilience outcomes.
- Ethiopia is home to the R4 Rural Resilience Initiative, which empowers rural households by offering integrated risk management services through Ethiopia's Productive Safety Net Programme and the marketplace. This includes parametric micro insurance, enabling subsistence farmers to receive payouts when rainfall is insufficient for their crops.
- The Tanzania Social Action Fund is a safety net programme that combines conditional cash transfers with climate resilient community investments to help manage future extremes and accelerate beneficiary transition out of the social protection system (known as 'graduation').

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planning processes and more effective use of climate extreme scenarios, between district, state and national units of government.

Looking ahead, local institutions need to be empowered with the resources and skills that enhance their flexibility and ability to identify a range of approaches to build anticipatory, absorptive and adaptive capacity. They must also be integrated with national and regional-scale systems that can inform and support them. Decentralisation processes currently being undertaken in a range of countries offer an opportunity to build better links.

6.2.2 Thinking globally; assessing risk locally

Poverty and climate extremes are often presented as global problems with local impacts. Analysis of the nature of the problem and how to address it will change depending on the scale of focus. While regional and global assessments are essential for understanding the scope of the challenge and cumulative impacts, evidence from the Philippines and Mali suggest local diagnosis is needed to provide a more accurate understanding of how risk and vulnerability are distributed. There are real limits to global analyses of risk and attempts to identify so-called vulnerability 'hotspots' for action where poverty and projected climate extremes coincide (see box 1). Instead, a more coordinated linking of macro-to-micro-scale analyses is required, drawing on the comparative strengths offered at each level.

Lessons from research conducted by the Climate and Development Knowledge Network suggest that for risk assessments to be useful for development planning, they need to be undertaken as part of an overall appraisal process that considers the whole range of costs and benefits of different investments. This process also needs to engage local producers and users of risk information in the design and implementation of these assessments. Inter-governmental and multi-scale partnerships can help create high quality assessment tools at the local level, where capacities are lower or non-existent, and will help promote geographical replication across local administrative units. This has happened in Costa Rica through the standardisation of disaster data, where local actors provide information on disaster impacts while the national government (along with universities) develops and updates the protocols for including this information in a national database, as well as providing training on how the system works (Wilkinson and Brenes, 2014).

6.2.3 Linking institutions and solutions

The climate extremes-poverty-disasters nexus presents challenges for coordination across different fields of policy and practice. Solutions that strengthen resilience and reduce poverty will need to link different institutions that have previously been poorly connected, such as social protection and early warning systems, or development and disaster insurance. Adaptive social protection programmes (see box 4) and the use of seasonal climate forecasts in disaster management planning (Braman et al., 2012) are promising

Box 5: Innovative financing to safeguard against climate extremes

New and innovative financing models for anticipating, absorbing and adapting to climate extremes are being trialled across a range of scales and settings, with some offering potential both for scaling up and out. As an example, risk pooling mechanisms that promote ex-ante investments in DRM or adaption are not yet common, but could help address an existing and growing need to be better equipped to manage climate extremes. These kinds of funding arrangements tend to be used to pay for emergency response, assisting countries that would not otherwise be able to pay through their budgets.

Since 2012, the Africa Risk Capacity (ARC) has been assisting African Union member states to reduce disaster impacts by providing targeted disaster response. Satellite technology is used to estimate and trigger readily available funds to African countries hit by severe weather events. This, combined with a disaster risk pool, reduces the cost to countries of responding to emergencies and decreases reliance on external aid. Through the newly created Extreme Climate Facility (XCF), ARC could provide financial coverage for African governments on a longer time horizon. This would involve focussing on the prospective increased incidence of extreme weather events over the coming decades, rather than only on sudden onset events and inter-annual rainfall variation. The XCF will provide additional funds to countries that are already managing their weather risks with ARC and located in regions that experience a detectable increase in the frequency and severity of extreme events. This will allow countries to implement or scale-up their climate adaptation and/or DRM plans in the regions where such investments are most needed.

As another example, Index-based disaster insurance programmes – pioneered in Ethiopia, Mexico, Nicaragua, Vietnam, the Caribbean and Malawi – are now gaining popularity around the world as a way of building the resilience of poor farmers to climate extremes. Index-based products have been able to overcome some of the limitations of traditional disaster insurance, by reducing the transaction cost and justifying entry of insurers and extension of their coverage to poor people. Along with this, the insured do not need to be active bank customers to be eligible, as they do with other types of insurance. Such systems can only function where there are monitoring systems in place to track the inception, growth and termination of weather hazards and this requires investment in the support infrastructure and technical capacities. One of the most useful options for poor farmers using rainfall index insurance is linking it to credit. In this way, a loan used to purchase inputs to increase productivity is protected from drought risk. With an unprotected loan if the required rains fail, a farmer would not only suffer crop failure, but would still be required to repay the loan. With an insured loan, however, the loan repayment would be covered should the crop fail, avoiding driving the farmer further into poverty.

Written by Emily Wilkinson

as examples of coordinated planning and response between entities that have historically not been well linked.

Fundamental changes to policies and decision-making processes are needed for many of these approaches to be taken up at a wide scale and in a sustained way, involving reconfigurations of institutional and power relations across scales of governance. The example of decentralisation of drought risk management in Kenya is a good example of this kind of reform (see box 3).

6.2.4 Finance as a catalyst for transformation

Risk financing is not a panacea for enhancing resilience capacities, particularly not in lower-income countries, but when designed effectively it could play a catalytic role. The delivery of climate finance continues to fall short of commitments, while the cost of disasters continues to escalate globally, with more needing to be done to identify investments that will help achieve resilient poverty reduction in the face of future extreme events.

At the same time, there are innovations in financing models being developed or piloted in one field, such as enhanced direct principles being developed under the Green Climate Fund. These include those that devolve decision-making and resource management to national-level entities (Green Climate Fund, 2014) and new financing models for responding to climate extremes (see box 5) and can inform financing approaches elsewhere.

6.2.5 Defining poverty in dynamic terms

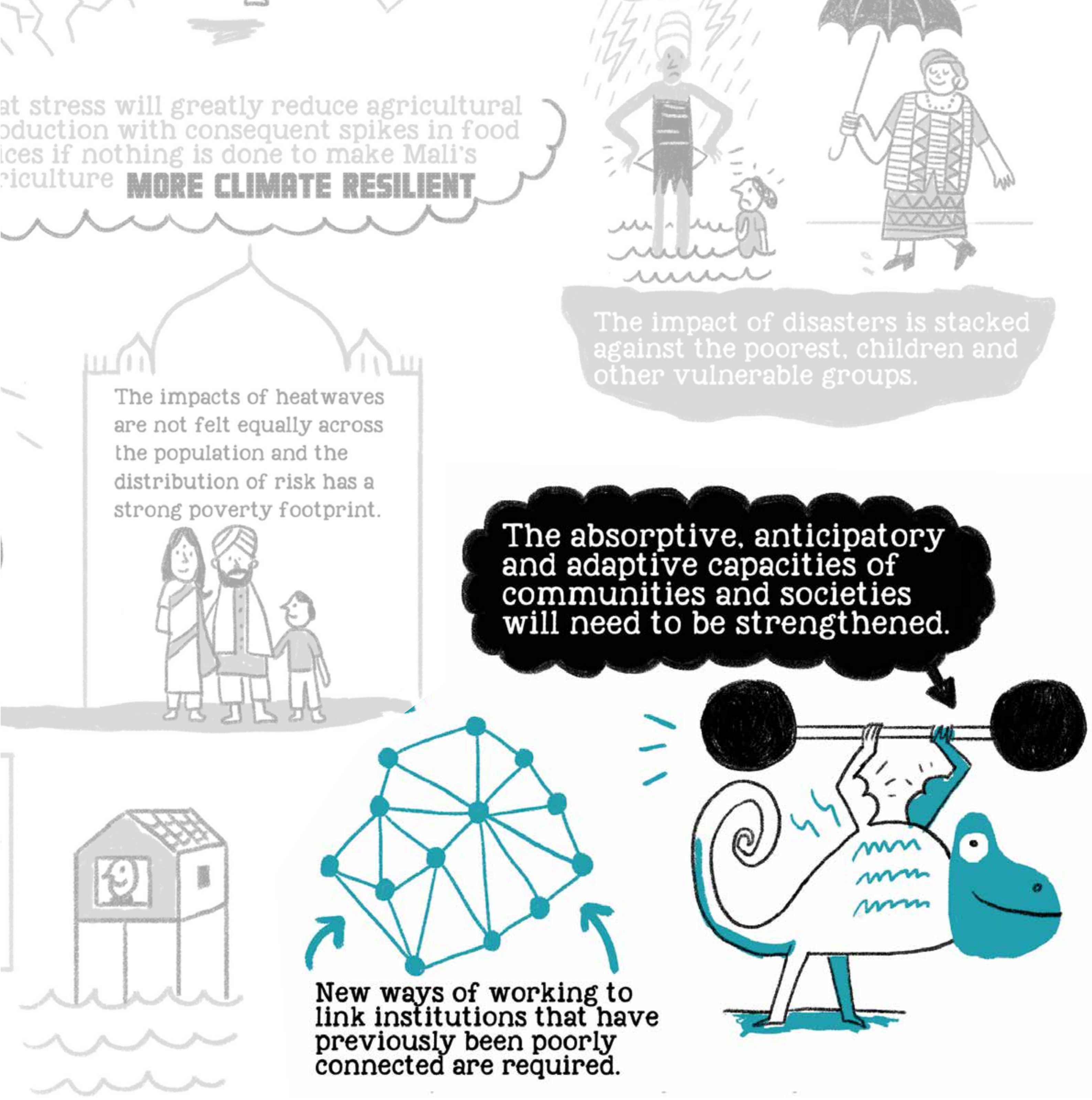
The findings of this report bring the need to better recognise the dynamic interplay between climate extremes and poverty to the fore; as a consequence, development actors must look at poverty reduction in new terms, in ways that explicitly deal with the uncertainty of future climate conditions. Acknowledging the role of climate-related shocks in influencing people's movements in and out of poverty forces us to think of being poor in less static terms. Poverty is a state from which some people move in and out, with climate and other shocks often affecting that movement (World Bank, 2015c). What becomes important from this perspective is people's resilience to poverty, not just their poverty level at one time (Tanner and Mitchell, 2008). Understanding how climate extremes and shocks force people in and out of poverty, particularly in cases of recurrent shocks, such as those seen in Mali, will be an essential aspect of strengthening resilience, especially where these extremes are projected to grow in frequency and severity. Targeted social protection programmes that aim to reach the poorest and most vulnerable can be adapted to take these dynamics into account so they reach those who might otherwise fall into poverty under a changing climate (see box 4).

Resilient poverty reduction will therefore need to:

- undertake measures to target those close to the poverty line, not just those under it
- strengthen the agency of local actors to plan and protect themselves from these shocks, through enhanced anticipatory, absorptive and adaptive capacity
- transform the institutions that shape people's access to knowledge and the resources needed to act in the face of increasing climate extremes and high levels of uncertainty.

6.3 Conclusion

A sea change is required in the way we act on poverty reduction, across scales. 'Business as usual' will not go far enough. Incremental changes to current systems can be a step in the right direction, but are not adequate for reaching either the depth or scale of change that will be required to achieve the coupled aims of poverty eradication and resilience to climate extremes. We must deal with the reality that structural and systemic barriers to resilience to poverty need to be lifted and that this can only be achieved in some contexts through transformational changes in policy architecture, institutions and financing arrangements. As the degree and scope of transformational change required is at once global and at every scale, it cannot be prescribed as a carbon copy to be replicated the world over. It can, however, be informed by new evidence generated through the analysis in this report.



CHAPTER 7

Ensuring resilient poverty reduction

To meet our global SDG commitment to eliminating extreme poverty, we need to build resilience alongside ambitious global commitments to reduce greenhouse gas emissions and decarbonise development. Both are needed if we are to avoid even more catastrophic climate extremes in the long-term. Reaching and sustaining zero extreme poverty requires our collective effort to build resilience to the impacts of current climate extremes and projected climate changes.

This report provides new insights on the climate extremes-disasters-poverty nexus. This chapter discusses the main findings of the analysis and presents policy recommendations for addressing the interconnected challenges of managing climate extremes, reducing disaster risk and eliminating extreme poverty.

7.1 Key findings from the report

7.1.1 Climate extremes are an increasing problem

Our climate has warmed in the past 50 years (IPCC, 2014a) and patterns of extreme events have also shifted (IPCC, 2012). Global trends include a decrease in the number of cold days and nights, and an increase in the number of warm days and nights, but when we look more closely at the climate data, there are huge regional variations. Overall, we have seen extreme events, like those experienced recently in Mali, India and the Philippines, becoming more frequent.

Changes in climate extremes need to be studied at the local level, as what is considered 'extreme' occurs in relation to what is 'normal' in a specific context. In the West African Sahel, for example, there has been high variability in rainfall in recent years, with implications for both droughts and floods. In the Philippines, Super Typhoon Haiyan is considered to have been a 'very extreme event', breaking records as one of the strongest tropical storms to ever make landfall. Extreme heat, meanwhile, is one of the most easily identifiable effects of human-induced climate change and there has been a steady rise in the number of extreme hot days in most of the world since 1997 (Seneviratne et al., 2014).

To avoid surpassing a 2°C global mean temperature rise (above pre-industrial levels), we need to achieve zero net GHG emissions before 2100 (Granoff et al., 2015), which means emissions peaking by 2030. Even if this is possible, we are likely to see more of the kinds of extremes highlighted in this report over the next 15 years, including climate extremes of a higher frequency and intensity in some places, along with greater variability and uncertainty in many more. As climate change continues, especially if we exceed a 2°C global mean temperature increase, these changes in extremes will become increasingly difficult to manage in a growing number of places. The science explaining the relationship between global warming and extreme events and, in turn, for modelling future changes in those extreme events, has been improving rapidly. Still, much remains unknown and while we can anticipate certain patterns of increasing risk, we will never be able to fully predict the occurrence of specific extreme events in all places. This is the challenge we face when managing future climate risk.

7.1.2 Climate extremes have multiple poverty impacts across scales

This report focuses on the poverty impacts of climate extremes at the sub-national level. The impact on poverty and the multiple effects disasters have on the poor themselves may collectively be more damaging to poverty reduction efforts than increasing average temperatures alone, at least over the next 30 years. In the literature and case studies presented here, we see climate extremes affecting poverty levels by pushing people below the poverty line – for example, in the Philippines, estimates suggest that 2.3 million people may have been pushed below the national poverty line as a result of Super Typhoon Haiyan (GFDRR, 2014). Poverty is dynamic and there is strong evidence to suggest millions move in and out of it every day. This is due to abrupt changes in levels of consumption brought about by different shocks and stresses, of which climate extremes are just one kind.

In all three case studies, climate extremes are seen to affect the poor because of their high levels of exposure and vulnerability. For all three types of events, we see a disproportionate impact on those who live below the poverty line and suffer from non-income dimensions of poverty, such as poor housing. We also see a range of types of impacts on the poor, including those felt directly by the household, those that are indirect and via development impacts, and effects that are short- and longer-term (see table 1, chapter 1). The immediate impacts on poor households described in this report include loss of life (and associated loss of household earnings), along with illness, loss of crops and other assets; meanwhile, longer-term effects include increases in the price of staple foods and a reduction in food security, along with malnourishment, malnutrition and stunting in children, as well as lower educational attainment.

In the Philippines, households dependent on fishing and farming activities suffered the most after Super

Typhoon Haiyan, with fisheries and coconut farmers particularly badly affected. Beyond the immediate aftermath of Haiyan, the increased cost of living in Tacloban put further pressure on poor households. Drought, on the other hand, generally leads people to sell off their assets, reduces levels of consumption and can result in malnutrition; the drought affecting the whole of the Western Sahel during 2011-2012 saw a reduction in food availability. Combined with conflict and instability in the north of Mali, this generated food insecurity for most of the population in that area and, over the longer-term, has led to stunting in children. In India, heat stress has caused illness and affected incomes and productivity when places of employment are closed temporarily or people are too unwell to work.

Indirect impacts of climate extremes are felt not only by poor households living in affected areas but also by those in other parts of the country, through knock-on effects (see table 1, chapter 1). These are transmitted through a number of different mechanisms, including drops in productivity and economic growth, along with loss of government assets, service disruption and the diversion of government spending to response activities. Nevertheless, income distribution and inequality are crucial to impacts. National development indicators do not always reflect the severe consequences of disaster for the poorest members of society and care needs to be taken in interpreting impacts at this level. For example, Super Typhoon Haiyan caused major service disruption, but does not appear to have had a negative effect on national growth rates, even though poor households in the area affected by Haiyan saw a 40% drop in income (GFDRR, 2014).

7.1.3 There is no simple co-location of climate extremes and poverty

This report demonstrates that the relationship between poverty and climate extremes is complex and there is no simple co-location of these two phenomena. Whether or not these phenomena interact spatially and create 'hotspots', around which to target interventions, depends on a number of factors. These include the type of climate extreme, location of the event and the type of impact (and hence how impact is transmitted). Drought can hit an agrarian area but have impacts elsewhere. It can even be spread throughout the whole economy, as we see in the case of Mali. Households are just as likely to be impacted in urban or densely populated areas, where demand is sensitive to food price fluctuations and cereal availability, as they are in places where high numbers of drought days have a direct impact on agricultural production.

Tropical storms, on the other hand, have an important localised impact on the poor, affecting those living in places directly damaged by high winds, storm surge and flooding. When these affect important economic centres like Manila, however, we would expect there to be an indirect impact on poor people living elsewhere in the Philippines, transmitted via the huge costs of recovery, economic slowdown and other system-wide effects.

7.1.4 Risk from climate extremes is increasing

This report highlights some parts of the world where patterns of extreme events are changing and risk is rising. Although climate science is improving and is better able to clarify climate change's contribution to extreme events at the global scale, it is not always clear what local patterns of rainfall, temperature or hazards will look like over the next 15-25 years, let alone the second half of the century. Nonetheless, it is likely that more poor people will be exposed to the changes that do occur. People's exposure is already changing as a result of wider trends, such as population growth and urbanisation. Problems are created by natural resource depletion, including deforestation and the destruction of mangroves on the coast, which provide natural protection against cyclones, storm surge and sea level rise.

In India, the risks of heatwaves are highest in urban areas because of the urban heat island effect and poor air quality. These combine to produce extreme urban heat, affecting the urban poor living in slums, homeless people, elderly people and those working outdoors. Those moving from rural to urban areas are particularly vulnerable to heat waves because they are generally poor and will most likely be moving to densely populated places with poor quality housing and restricted access to clean water and electricity. They will also be less connected to support networks and services than city dwellers.

Vulnerability is also increasing in places where shocks and stresses are recurrent, such as in the case of the Sahel. As noted in chapter 3, if households do not have the necessary time to fully recover from a drought, their vulnerability to subsequent shocks increases.

Overall, climate science is improving in terms of clarifying climate change's contributions at the global scale but, for several types of extremes and especially in some of the most vulnerable regions, there are no clear projections about what to expect. Subsequent poverty impacts are often more complex and multidimensional than can be accurately predicted far into the future. However, we have seen that drought and poverty are intimately linked through direct and indirect impacts as well as feedback loops. It can also be observed that increasing uncertainty and variability in seasonal patterns poses its own set of problems for building resilience to drought. For other extreme events, there is greater certainty: heat stress related illness and subsequent productivity losses in India's cities, along with widespread damage to low-income housing and productive assets in coastal areas of the Philippines, are set to increase if action is not taken to improve resilience.

7.2 Planning and policies for building resilience

This section identifies a set of messages for planners and policy makers that will help them to strengthen resilience and safeguard investments in poverty reduction.

7.2.1 Building adaptive, anticipatory and absorptive capacity

Tackling the combined challenges of poverty eradication and climate change requires action to build resilience capacities. Capacity at the local level shapes how impacts of extremes play out and affect patterns of poverty. By building the anticipatory, absorptive and adaptive capacities of those communities and societies most vulnerable to increasing climate risks, we can minimise the impact of climate extremes on poverty levels and the poor.

7.2.2 Building institutional capacities and strengthening systems

Building local capacities and strengthening systems will remain a cornerstone of efforts to build resilience to climate extremes. Capacity at the local level shapes how impacts of extremes play out and affect patterns of poverty. Continued investment into local DRM capacities and institutions is required, as well as efforts to strengthen coordination across scales of governance. Decentralisation processes can help empower local institutions and, when coupled with efforts to integrate local units within national and regional planning systems, can produce more effective local solutions to the risks posed by climate extremes.

7.2.3 The need to think globally and assess risk locally

This report emphasises the need to think globally about the poverty implications of climate extremes, but assess risk locally. While regional and global assessments are essential for understanding the scope of the climate challenge, local diagnosis is needed to provide a more accurate understanding of how risk is distributed. Analysis that connects macro-to-micro-scales, drawing on the comparative strengths offered at each level of analysis, will present a more nuanced and accurate picture of the climate change-disaster-poverty nexus.

7.2.4 Linking institutions and solutions

Solutions that strengthen resilience and reduce poverty will need to link different institutions that have previously been poorly connected. Analysis of the relationship between climate change, disaster and poverty reveals some important gaps in connectivity and coordination across fields of policy and practice. More joined up ways of working across sectors and scales may be required, using climate and weather information and scenarios to inform planning.

7.2.5 The role of transformative action

Building adaptive, anticipatory and absorptive capacities incrementally may not be enough to secure resilient poverty reduction in the face of climate change. The scale and scope of future climate risks, as identified in Mali, India and the Philippines, requires a transformational shift in the way risk is managed. Transformational changes can be catalytic in nature, leveraging change beyond the initial direct activities. They achieve change at scale, with outcomes of a high order of magnitude relative to resource inputs, or they can be sustainable over time, outlasting initial political and/or financial support.

7.2.6 Finance as a catalyst for transformation

Risk financing instruments have the potential to generate transformational changes by acting as a catalyst for further investment in disaster risk management and adaptation. Regional financing mechanisms can also help countries to scale up these investments in places where they are most needed. Finance is not a panacea and has limitations in some developing contexts, but it can and does offer opportunities for new ways to manage risk that warrant further attention as part of a portfolio of solutions.

7.3 Achieving our global goals

The impoverishing impact of both climate change and disasters has been acknowledged internationally. In particular, the very first SDG is a commitment to end extreme poverty and includes a specific target to 'build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters' (United Nations, 2015a:15). This is in addition to a separate goal on action to combat climate change and its impacts, and the attention to resilience in the goal on safe and sustainable cities and settlements. These SDG targets reinforce commitments to action in complementary international agreements, such as the 2015 Sendai Framework for Disaster Risk Reduction (UNISDR, 2015) and outcomes of UNFCCC COP21.

The findings of this report are timely, coinciding with the early implementation of international frameworks that seek to build resilience capacities. These frameworks should serve as vehicles for promoting the kinds of transformative change that are needed at national and sub-national levels. The Sendai Framework on Disaster Risk Reduction and outcomes of the World Humanitarian Summit provide complementary opportunities to build anticipatory and absorptive capacities, while elements of the Sendai Framework also promote greater adaptive capacity, emphasising the need to mainstream risk management into development approaches. An ambitious commitment to supporting adaptation efforts through the UNFCCC negotiations at COP21 would contribute significantly to these efforts.

Taken as a package, these 2015–2016 international frameworks provide different entry points for joining up efforts and addressing development challenges at the climate change-disaster-poverty nexus.

For all of these goals to succeed, especially the elimination of extreme poverty, countries will need to ensure their development trajectories do not maintain or exacerbate climate risks. Instead, they will need to harness the breadth of financial, technical and policy mechanisms in place to build resilience in light of climate extremes and uncertainty. This requires analysis and action across scales, whereby national policies and investments are connected to local analysis and management of rising risks and uncertainties.

This is the challenge ahead.


Early warning systems, climate and harvest monitoring have been shown to help anticipate food crises and reduce poverty
800 million rural dwellers cut off in the rainy season
MALI is highly vulnerable to drought and flood events.
CLIMATE CHANGE POSES A THREAT TO DEVELOPMENT GOALS
1.3 BILLION PEOPLE LACK ACCESS TO ELECTRICITY
CLIMATE CHANGE
900 million without access to CLEAN WATER
Climate change will slow down economic growth, make poverty reduction more difficult and will erode food security.
10% of the world's population live on less than $1.90 a day

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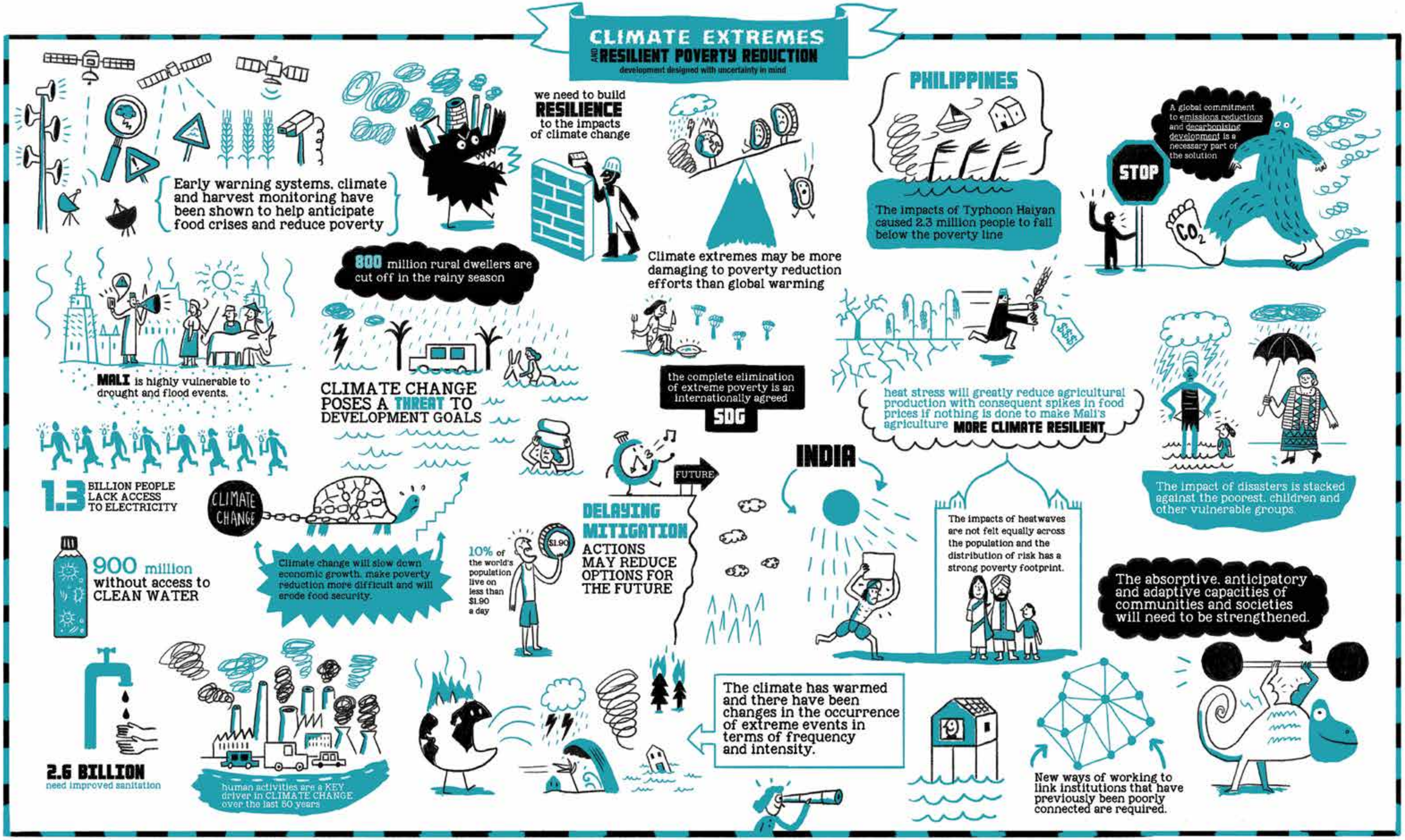
CLIMATE EXTREMES
AND RESILIENT POVERTY REDUCTION
development designed with uncertainty in mind
Early warning systems, climate and harvest monitoring have been shown to help anticipate food crises and reduce poverty
we need to build RESILIENCE to the impacts of climate change
Climate extremes may be more damaging to poverty reduction efforts than global warming
PHILIPPINES
The impacts of Typhoon Haiyan caused 2.3 million people to fall below the poverty line
A global commitment to emissions reductions and decarbonising development is a necessary part of the solution
STOP
CO2
MALI is highly vulnerable to drought and flood events.
800 million rural dwellers are cut off in the rainy season
CLIMATE CHANGE POSES A THREAT TO DEVELOPMENT GOALS
the complete elimination of extreme poverty is an internationally agreed SDG
$$$
heat stress will greatly reduce agricultural production with consequent spikes in food prices if nothing is done to make Mali's agriculture MORE CLIMATE RESILIENT
The impact of disasters is stacked against the poorest, children and other vulnerable groups.
1.3 BILLION PEOPLE LACK ACCESS TO ELECTRICITY
CLIMATE CHANGE
Climate change will slow down economic growth, make poverty reduction more difficult and will erode food security.
FUTURE
DELAYING MITIGATION ACTIONS MAY REDUCE OPTIONS FOR THE FUTURE
10% of the world's population live on less than $1.90 a day
$1.90
INDIA
The impacts of heatwaves are not felt equally across the population and the distribution of risk has a strong poverty footprint.
900 million without access to CLEAN WATER
The absorptive, anticipatory and adaptive capacities of communities and societies will need to be strengthened.
2.6 BILLION need improved sanitation
human activities are a KEY driver in CLIMATE CHANGE over the last 50 years
The climate has warmed and there have been changes in the occurrence of extreme events in terms of frequency and intensity.
New ways of working to link institutions that have previously been poorly connected are required.

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