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Managing Climate Extremes and Disasters in Africa: Lessons from the IPCC SREX Report

Contents

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1. Introduction to the Special Report

1.1 About the SREX report

The Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) was commissioned by the Intergovernmental Panel on Climate Change (IPCC) in response to a recognised need to provide specific advice on climate change, extreme weather and climate events ('climate extremes'). The SREX report was written over two and a half years, compiled by 220 expert authors, 19 review editors and taking account of almost 19,000 comments. It went through three rigorous drafting processes with expert and government review. The findings were approved by the world's governments following a four-day meeting, where the Summary for Policy Makers was agreed. It thus provides the best scientific assessment available to date. It comprises a policy summary released in November 2011 and the full report released in March 2012 (available online at http://ipcc-wg2.gov/srex).

This summary highlights the key findings of the SREX report from an African perspective, including an assessment of the science and the implications of this for society and sustainable development. The SREX report considers the effects of climate change on extreme events, disasters, and disaster risk management (DRM). It examines how climate extremes, human factors and the environment interact to influence disaster impacts and risk management and adaptation options (see Figure 1). The SREX report considers the role of development in exposure and vulnerability, the implications for disaster risk, and the interactions between disasters and development. It examines how human responses to extreme events and disasters could contribute to adaptation objectives, and how adaptation to climate change could become better integrated with DRM practice. The SREX report represents a significant step forward for the integration and harmonisation of the climate change adaptation, disaster risk management and climate science communities.

Although not an official publication of the IPCC, this summary has been written under the supervision of co-authors of the SREX report and it has been thoroughly reviewed by an expert scientific panel. The summary includes material directly taken from the SREX report, where the underlying source is clearly referenced, but it also presents synthesis messages that are the views of the authors of this summary and not necessarily those of the IPCC. It is hoped that the result will illuminate the SREX report's vital findings for decision makers in Africa, and so better equip them to make sound investments to reduce disaster risk in a changing climate.

1.2 Ten Key Messages

Key summary messages from the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation for the Africa region:[1]

1. Even without taking climate change into account, disaster risk will continue to increase in many African countries as more vulnerable people and assets are exposed to weather extremes.
2. Based on data since 1950, evidence suggests that climate change has changed the magnitude and frequency of some extreme weather and climate events in some global regions already.
3. In the next two or three decades, the expected increase in climate extremes will probably be relatively small compared to the normal year-to-year variations in such extremes. However, as climate change impacts become more dramatic, its effect on a range of climate extremes in Africa will become increasingly important and will play a more significant role in disaster impacts.
4. There is better information on what is expected in terms of changes in extremes in various regions and sub-regions, rather than just globally (see Table 1 and Figure 2); though for some regions and some extremes uncertainty remains high (e.g. precipitation trends across most of Africa).
5. High levels of vulnerability, combined with more severe and frequent weather and climate extremes, may result in some places, such as African coastal cities, being increasingly difficult places in which to live and work.
6. A new balance needs to be struck between measures to reduce risk, transfer risk (e.g. through insurance) and effectively prepare for and manage disaster impact in a changing climate. This balance will require a stronger emphasis on anticipation and risk reduction.
7. Existing risk management measures need to be improved as many countries are poorly adapted to current extremes and risks, so are not prepared for the future. This would include a wide range of measures such as early warning systems, land use planning, development and enforcement of building codes, improvements to health surveillance, or ecosystem management and restoration. In Kenya for example, the government is working towards a national disaster management policy to build resilience to hazard events and ensure that disaster policy is integrated with development policy and poverty reduction.
8. Countries' capacity to meet the challenges of observed and projected trends in disaster risk is determined by the effectiveness of their national risk management system. Such systems include national and sub-national governments, the private sector, research bodies, and civil society including community-based organisations.
9. More fundamental adjustments are required to avoid the worst disaster losses and tipping points where vulnerability and exposure are high, capacity is low and weather extremes are changing.
10. Any delay in greenhouse gas mitigation is likely to lead to more severe and frequent climate extremes in the future and will likely further contribute to disaster losses.

1.3 The implications of this for Africa are as follows:

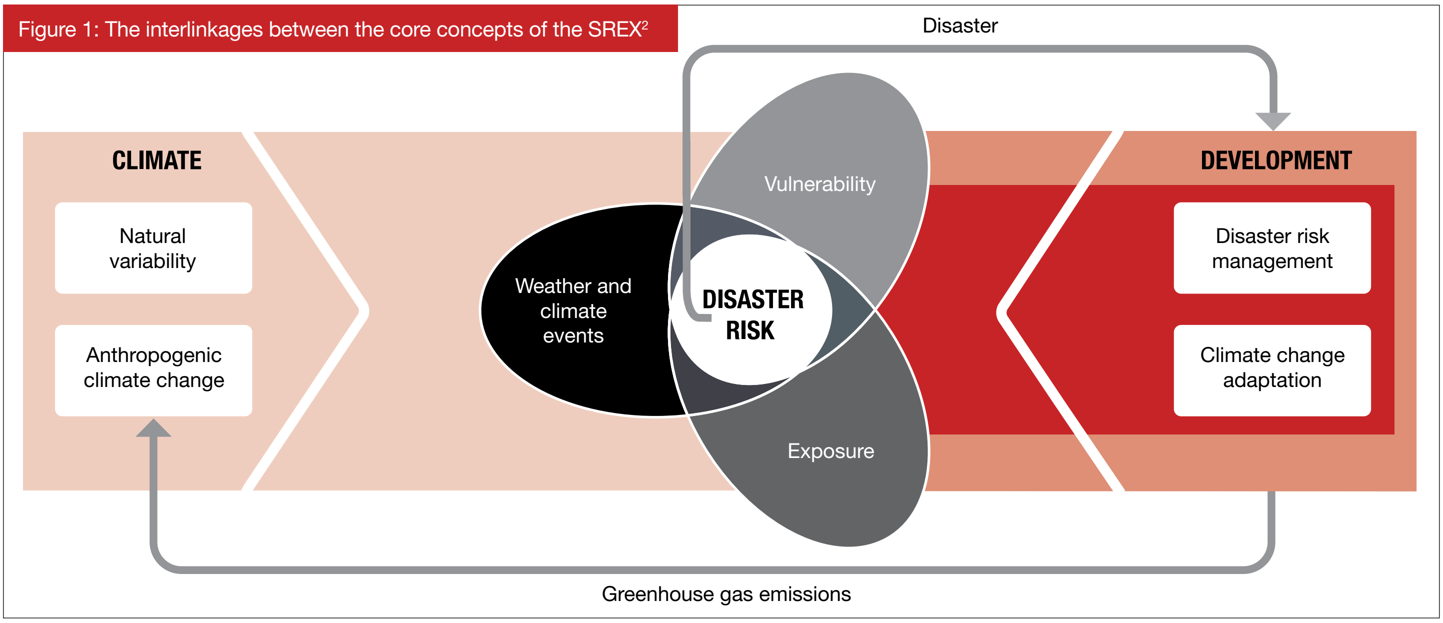
- There is a need for countries to reassess their investments in measures to manage disaster risk. This needs to be fully integrated into planning processes, including e.g. through improved continuous data collection for floods, droughts and cyclones.
- There is a need for new and better disaster risk assessments that take climate change into account, which may require countries and people to reassess their thinking on what levels of risk they are willing and able to accept.
- It will be important to strengthen new and existing partnerships for reducing risk, e.g. including with the private sector and bilateral and multilateral agencies. Mutual learning within Africa will be important.
- There is a need to strengthen the integration of financial and programming mechanisms to support adaptation and risk management across development sectors and the vertical and horizontal levels of governance and agencies.
- It will be important to highlight changing climate-related disaster risks to policy makers working in other policy domains.
- There is a need to reaffirm the importance of mitigating greenhouse gases globally in order to avoid the worst climate extremes and their associated impacts across Africa.
- There must be consideration that in some cases today's climate extremes will be tomorrow's 'normal' weather. Tomorrow's climate extremes may therefore stretch our imagination and challenge our capacity to manage change as never before.
- There is a need for much smarter development and economic policies that consider changing disaster risk as a core component. Without this it is likely that an increasing number of people and assets will be adversely impacted by future climate extremes and disasters.

1. Highlights from a note by Dr. Tom Mitchell, Overseas Development Institute and Dr. Maarten van Aalst, Red Cross/Red Crescent Climate Centre available at http://cdkn.org/2011/11/ipcc-srex.

2. Changing disaster risks

This section looks at the components of changing disaster risk in more detail. The inter-linkages between the core concepts discussed in the SREX report are illustrated in Figure 1. This shows how both changes in vulnerability and exposure and changes in weather and extreme climate events can contribute and combine to create disaster risk, hence the need for both disaster risk management (DRM) and climate change adaptation (CCA) within development processes.

Figure 1: The interlinkages between the core concepts of the SREX[2]



2. Lavell, A., M. Oppenheimer, C. Diop, J. Hess, R. Lempert, J. Li, R. Muir-Wood, and S. Myeong, 2012: Climate change: new dimensions in disaster risk, exposure, vulnerability, and resilience. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 25-64.

2.1 Changes in vulnerability and exposure[3]

Vulnerability and exposure are dynamic and depend on economic, social, demographic, cultural, institutional, and governance factors. Individuals and communities are differentially exposed based on factors such as wealth, education, gender, age, class/caste, and health. Lack of resilience and capacity to anticipate, cope with and adapt to extremes are important factors of vulnerability. For example, a tropical cyclone can have very different impacts depending on where and when it makes landfall. Similarly, a heat wave can have very different impacts on different population groups depending on their vulnerability. Extreme impacts on human, ecological, or physical systems can therefore result from individual extreme weather or climate events, from non-extreme events where exposure and vulnerability are high, or from a compounding of events or their impacts.

High vulnerability and exposure are generally the outcome of skewed development processes, e.g. environmental mismanagement, demographic change, rapid and unplanned urbanisation, failed governance, and a scarcity of livelihood options. This can result in settlements in hazard prone areas, the creation of unsafe dwellings, slums and scattered districts, poverty and lack of awareness of risks. For example, those with awareness, transferable livelihoods, money and access to transport can move away from disaster areas and live more comfortably out of danger. Those without these assets may be forced to locate their homes in hazard prone areas where they are more vulnerable and exposed to climate extremes. They will also have to deal with the impacts of disaster on the ground, including no water, food, sanitation or shelter.

Changing patterns of vulnerability and exposure are a key driver of risk and disaster losses. Understanding the multi-faceted nature of both exposure and vulnerability is a prerequisite for determining how weather and climate events contribute to the occurrence of disasters, and for designing and implementing effective adaptation and disaster risk management strategies. Decision- and policy-making therefore needs to be based on the nature of vulnerability and exposure and not only on the hazard itself.

2.2 Changes in extreme events

Defining climate extremes[4]

A changing climate leads to changes in the frequency, intensity, spatial extent and duration of weather and climate extremes, and can result in unprecedented extremes. 'An *extreme (weather or climate) event* is generally defined as the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends ('tails') of the range of observed values of the variable' (see glossary).

Box 1: What can policy makers expect from climate science?

- **The quality of information will differ between global, regional and local scales.**
- **There will be differences in what the science can say about extremes, e.g. the links between rises in temperature and sea level rise are more clear than the links between rises in temperature and an increase in frequency or intensity of storms.**
- **Variability is always important. Climate trends are usually only one factor in the probability of hazards – in some regions and for some decisions, seasonal variability may be more important than long-term trends.**
- **For decisions affecting just the next decade, it may be more important to think about what has changed already and what the near-term range of variability is, rather than what will happen in the coming century.**
- **In many cases, all we know is that risks are rising, because uncertainty is increasing, with sometimes some hints on future trends or ranges of uncertainty – there is seldom specific information on precise future probabilities of particular extremes.**
- **These factors should be considered when reviewing climate science for decision- and policy-making. However, uncertainty should not be used as a reason for inaction with regard to investing in reducing vulnerability and exposure. SREX provides enough information to show that more people and assets are in harm's way and much more can be done to reduce exposure, vulnerability and risk.**

3. Draws on material from SREX Chapter 2, Cardona, O.M. et al, 'Determinants of Risk: Exposure and Vulnerability', and Chapter 4, Handmer, J. et al, 'Changes in Impacts of Climate Extremes: Human Systems and Ecosystems'.
4. Draws on material from SREX Chapter 3, Nicholls. N. et al, 'Changes in Climate Extremes and their Impacts on the Natural Physical Environment'.

2.3 Changes in climate extremes affecting the region

The SREX report provides robust scientific information on what can be expected from changes in weather and climate extremes in various regions and sub-regions of Africa. A summary of this information is captured in Table 1 and 2.

Key

Symbols

- Increasing trend
- Decreasing trend
- Varying trend
- Inconsistent trend/insufficient evidence
- No or only slight change

Level of confidence in findings

- Low confidence
- Medium confidence
- High confidence

Table 1: Observed changes in temperature and precipitation extremes since the 1950s[5]

Table 1 shows observed changes in temperature and precipitation extremes, including dryness in regions of Africa since 1950, with the period 1961-1990 used as a baseline (see Box 3.1 in Chapter 3 of SREX for more information).

Region and Sub-region	Trends in maximum temperature (warm and cold days)[6]	Trends in minimum temperature (warm and cold nights)[7]	Trends in heat waves/ warm spells[8]	Trends in heavy precipitation (rain, snow)[9]	Trends in dryness and drought[10]
West Africa	Significant increase in temperature of warmest day and coolest day in large parts Insufficient evidence in others	Decreasing frequency of warm nights, decrease in cold nights in large parts Insufficient evidence in others	Insufficient evidence for most of the region	Precipitation from heavy rainfall events decreased in many areas, rainfall intensity increased	Increased dry spell duration, greater inter-annual variation in recent years
East Africa	Lack of evidence due to lack of literature and spatially non-uniform trends	Spatially varying trends in most areas Increases in warm nights in Southern tip (decreases in cold nights)	Insufficient evidence	Insufficient evidence	Spatially varying trends in dryness
Southern Africa	Increase in warm days (decrease in cold days)	Increase in warm nights (decrease in cold nights)	Increase in warm spell duration	No spatially coherent patterns of trends in precipitation extremes	General increase in dryness
Sahara	Lack of literature	Increase in warm nights Lack of literature on trends in cold nights	Insufficient evidence	Insufficient evidence	Limited data, spatial variation of the trends

5. Period 1961-1990 used as a baseline.
6. Refers to the number of warm days and cold days with maximum temperature above or below extreme values e.g. the 90th/10th percentile with respect to the 1961-1990 reference period.
7. Refers to the number of warm nights and cold nights with minimum temperature above or below extreme values, e.g. the 90th/10th percentile with respect to the 1961-1990 reference period.
8. Warm spell refers to periods of at least six days where maximum temperature values exceed the 90th percentile with respect to the 1961-1990 reference period.
9. Refers to the number of days with precipitation above an extreme value, e.g. the 90th percentile, with respect to the 1961-1990 reference period.
10. Dryness is calculated in relation to a number of variables including: number of consecutive dry days (dry is defined as daily precipitation with <1 mm); soil moisture anomalies; and drought severity index. Dryness refers to a hydro-meteorological water deficit, whereas drought is extended and continuous water shortage. More information is given in Box 3.3 of Chapter 3 in the SREX report.

Table 2: Projected changes in temperature and precipitation extremes, including dryness, in Africa

Table 2 shows projected changes in temperature and precipitation extremes, including dryness, in Africa. The projections are for the period 2071-2100 (compared with 1961-1990) or 2080-2100 (compared with 1980-2000) and are based on GCM and RCM[11] outputs run under the A2/A1B emissions scenario.

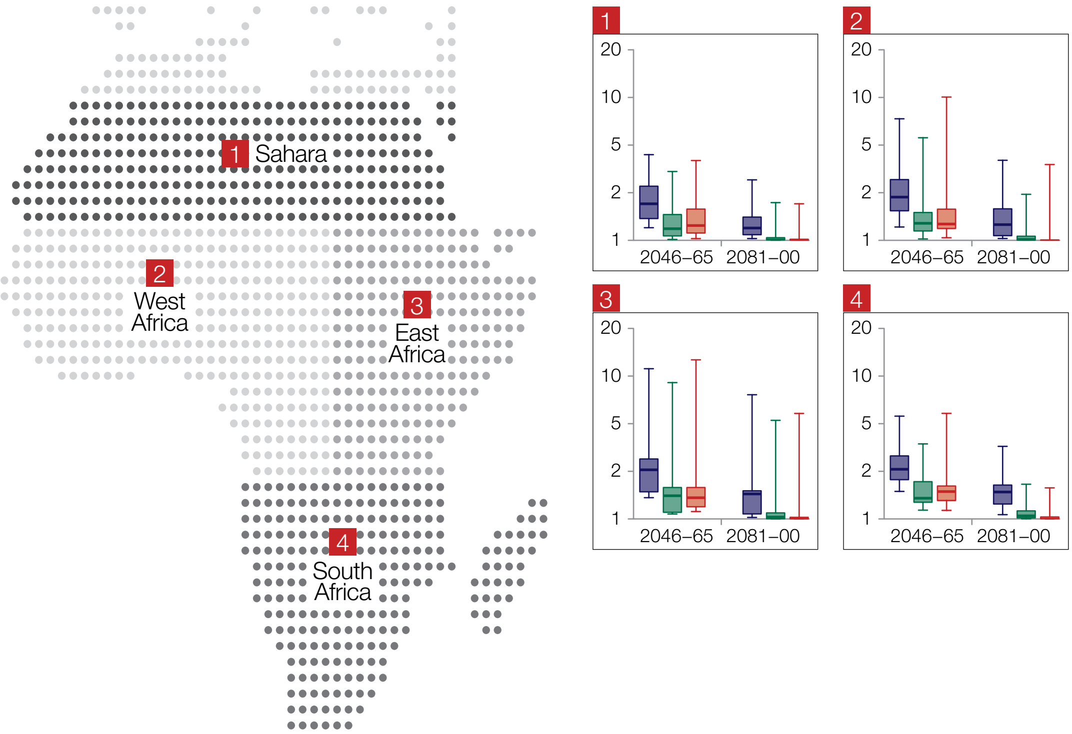
Region and Sub-region	Trends in maximum temperature (the frequency of warm and cold days)[12]	Trends in minimum temperature (the frequency of warm and cold nights)[13]	Trends in heat waves/ warm spells[14]	Trends in heavy precipitation (rain, snow)[15]	Trends in dryness and drought[16]
West Africa	Likely increase in warm days (decrease in cold days)	Likely increase in warm nights (decrease in cold nights)	Likely more frequent and/or longer heat waves and warm spells	Slight or no change in heavy precipitation indicators in most areas Low model agreement in northern areas	Inconsistent signal
East Africa	Likely increase in warm days (decrease in cold days)	Likely increase in warm nights (decrease in cold nights)	Likely more frequent and/or longer heat waves and warm spells	Likely increase in heavy precipitation	Decreasing dryness in large areas
Southern Africa	Likely increase in warm days (decrease in cold days)	Likely increase in warm nights (decrease in cold nights)	Likely more frequent and/or longer heat waves & warm spells	Lack of agreement in signal for region as a whole Some evidence of increase in heavy precipitation in southeast regions	Increase in dryness, except eastern part Consistent increase in area of drought
Sahara	Likely increase in warm days (decrease in cold days)	Likely increase in warm nights (decrease in cold nights)	Likely more frequent and/or longer heat waves and warm spells	Low agreement	Inconsistent signal of change

11. GCM refers to Global Circulation Model, RCM refers to Regional Climate Model.
12. Refers to the number of warm days and cold days with maximum temperature above or below extreme values e.g. the 90th/10th percentile in 2071-2100 with respect to the 1961-1990 reference period.
13. Refers to the number of warm nights and cold nights with temperature extremes above or below extreme values, e.g. the 90th/10th percentile in 2071-2100 with respect to the 1961-1990 reference period.
14. Warm spell refers to periods of at least six days where extreme temperature values exceed the 90th percentile in 2071-2100, with respect to the 1961-1999 reference period.
15. Refers to the number of days with precipitation above an extreme value, e.g. the 95th percentile, or above 10mm in one day in 2071-2100, with respect to the 1961-1990 reference period.
16. Dryness is calculated in relation to a number of variables including: number of consecutive dry days (dry is defined as daily precipitation with <1 mm); soil moisture anomalies; and drought severity index Dryness refers to a hydro-meteorological water deficit, whereas drought is extended and continuous water shortage. More information is given in Box 3.3 of Chapter 3 in the SREX report.

Figure 2: Projected return period (in years) of late 20th century 20-year return values of annual maximum (a) of the daily maximum temperature; and (b) 24-hour precipitation rates[17]

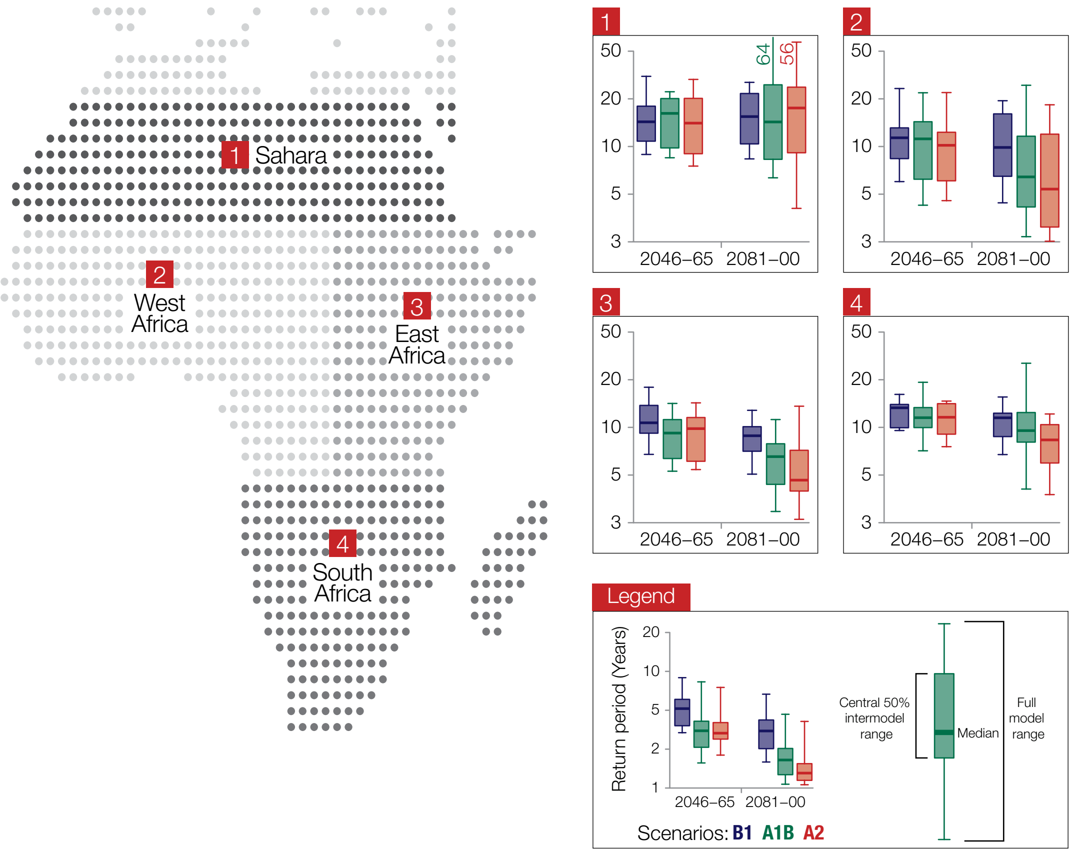
(a) Temperature

The temperature graph shows how often the hottest day in the last 20 years of the 20th century will be experienced by the middle and end of the 21st century. These are shown under three different emissions scenarios: B1, A1B and A2.[18] For example the hottest day experienced in the last 20 years at the end of the 20th century will occur at least biannually by 2046-65 across the continent and under both the A1B and A2 scenarios by 2100, every year, everywhere. What is now an extreme will become normal.



(b) Precipitation

The precipitation graph shows how often the wettest day in the last 20 years of the 20th century will be experienced by the middle and end of the 21st century. These are shown under three different emissions scenarios: B1, A1B and A2.[19] For example this shows that in East Africa the wettest day will become more frequent under any scenario and time period, whereas for Southern Africa, and particularly the Sahara, this will become a rarer occurrence, with increasing dryness the new normal.



17. Seneviratne, S.I., N. Nicholls, D. Easterling, C.M. Goodess, S. Kanae, J. Kossin, Y. Luo, J. Marengo, K. McInnes, M. Rahimi, M. Reichstein, A. Sorteberg, C. Vera, and X. Zhang, 2012: Changes in climate extremes and their impacts on the natural physical environment. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 109-230.

Observations and projections of trends in tropical cyclones and other relevant extremes are given in Table 3.

Table 3: Overview of considered extremes and summary of observed and projected changes on global scale

Phenomena related to weather and climate extremes		Observed changes (since 1950)	Attribution of observed changes	Projected changes (up to 2100) with respect to late 20th century
	Monsoons	*Low confidence* in trends because of insufficient evidence.	*Low confidence* due to insufficient evidence.	*Low confidence* in projected changes of monsoons, because of insufficient agreement between climate models.
	El Niño and other modes of variability	*Medium confidence* of past trends towards more frequent central equatorial Pacific El Niño Southern Oscillation (ENSO) events. Insufficient evidence for more specific statements on ENSO trends. *Likely* trends in Southern Annular Mode.	*Likely* anthropogenic influences on identified trends in Southern Annular Mode.[20] Anthropogenic influence on trends in NAO are *as likely as not*. No attribution of changes in ENSO.	*Low confidence* in projections of changes in behaviour of ENSO and other modes of variability because of insufficient agreement of model projections.
	Tropical cyclones	*Low confidence* that any observed long-term (i.e. 40 years old or more) increases in tropical cyclone activity are robust, after accounting for past changes in observing capabilities.	*Low confidence* in attribution of changes in tropical cyclone activity to anthropogenic influences (insufficient data quality and physical understanding).	*Likely* decrease or no change in frequency of tropical cyclones. *Likely* increase in mean maximum wind speed, but possibly not in all basins. *Likely* increase in heavy rainfall associated with tropical cyclones.
	Extratropical cyclones	*Likely* poleward shift in extratropical cyclones. *Low confidence* in regional changes in intensity.	*Medium confidence* in anthropogenic influence on poleward shift.	*Likely* impacts on regional cyclone activity but *low confidence* in detailed regional projections due to only partial representation of relevant processes in current models. *Medium confidence* in a reduction in the numbers of mid-latitude storms. *Medium confidence* in projected poleward shift of mid-latitude storm tracks.

18. These refer to three of the six possible IPCC emissions scenario groups used throughout their reports.
B1 describes a convergent world with rapid changes towards a service and information economy and introduction of clean and resource efficient technologies.
A1B describes rapid economic development and growth, with balanced technological development across all sources, i.e. neither fossil intensive nor all non-fossil sources. A2 is a heterogeneous world with self reliance and local identity, regional economic development, fragmented and slower growth. See www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf Figure 1 for more information.
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20. The Southern Annular Mode refers to the shifts (north and south) of atmospheric mass between middle and high latitudes. It is the most significant mode of variability outside the tropics in the Southern Hemisphere and plays an important role in climate variability in these latitudes. It has been associated with cooler than normal temperatures over most of Antarctica and Australia, with warm anomalies over the Antarctic Peninsula, southern South America, and southern New Zealand, and with anomalously dry conditions over southern South America, New Zealand, and Tasmania and wet anomalies over much of Australia and South Africa (e.g., Hendon et al., 2007).

Box 2: Extreme weather events and disasters in Africa – beyond SREX

- **Between 1980 and 2010 Africa suffered 27% of the world's reported fatalities from natural catastrophes (614,250 people).**
- **Between 1980 and 2010 Africa experienced 1,560 weather-related catastrophes.**
- **In 2009 more than 100,000 people faced floods in West Africa, particularly Burkina Faso.**
- **Between October 2010 and September 2011 severe droughts in East Africa caused 50,000 fatalities and affected 13.3 million people.**

Source: Münchener Rückversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE, 2011.

2.4 Consequences of climate extremes[21]

This section builds on the information presented in the preceding tables and graphics to highlight what these changes in weather and climate extremes mean for Africa. It provides examples of the consequences and impacts that arise from a sample of climate extremes common to the Africa region. Marginalised groups (including women, children and the old) will, as ever, be more particularly vulnerable to climate extremes. The science base also shows how non-extreme climate-related events, rather than 'extreme' events, can result in extreme consequences where vulnerability is high.

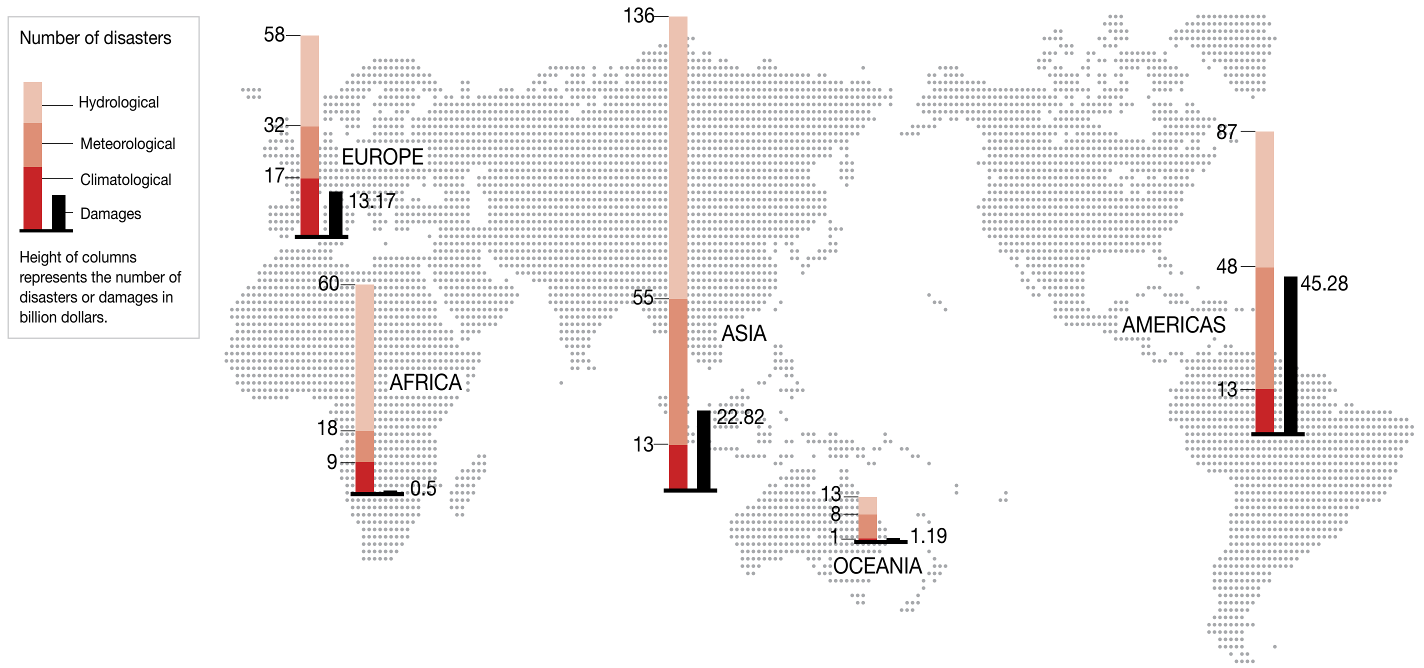
Drought: Droughts have affected the Sahel, the Horn of Africa, and Southern Africa particularly since the end of the 1960s. For example in the 1980s Sahel drought caused many casualties and important socio-economic losses. Impacts of drought can be both direct (e.g. famine, death of cattle, soil salinisation), and also indirect (e.g. illnesses such as cholera and malaria). One of the main possible consequences of multi-year drought periods is severe famine (although there are other social, political and economic factors affecting the occurrence of a famine).

Floods can be highly beneficial in African drylands (e.g. Sahara and Namib deserts) since floodwaters infiltrate and recharge alluvial aquifers along river pathways, extending water availability to dry seasons and drought years. However, recurrent flooding can also result in major economic and human loss, for example in Mozambique and Somalia. In communities with less developed infrastructure and health services, impacts of floods are often exacerbated by health problems associated with water scarcity and quality, e.g. malnutrition, diarrhoea, cholera and malaria.

Heat stress: Heat extremes can claim casualties in tropical countries, even where people are acclimatised to a hot climate. In urban areas, heatwaves can also have negative effects on air quality and the number of days with high pollutants, ground level ozone, and suspended particle concentrations. Additionally, extreme heat can reduce the yield of grain crops such as corn and increase stress on livestock.

Tropical cyclones: In relative terms, Africa (especially Madagascar and Mozambique) has the largest increase in physical exposure to tropical cyclones. Damages from tropical cyclones are perhaps most commonly associated with extreme wind, but storm-surge and fresh-water flooding from extreme rainfall generally cause the great majority of damage and loss of life. Projected sea level rise is expected to further compound tropical cyclone surge impacts.

Figure 3: Weather and climate related disasters and regional average impacts (damages in US$ billion) from 2000-2008[22,23]



21. Draws on material from SREX Chapter 4, Handmer, J. et al, 'Changes in Impacts of Climate Extremes: Human Systems and Ecosystems'.
22. From Vos et al, 2010.
23. Handmer, J., Y. Honda, Z.W. Kundzewicz, N. Arnell, G. Benito, J. Hatfield, I.F. Mohamed, P. Peduzzi, S. Wu, B. Sherstyukov, K. Takahashi, and Z. Yan, 2012: Changes in impacts of climate extremes: human systems and ecosystems. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 231-290.

3. Future impacts

This section looks ahead to explore the range of possible future impacts for the region, considering points 3, 4 and 5 in the key messages (section 1.2) in more detail.

Impacts of extremes on human systems and eco systems

As shown in section 2, changing climate extremes may result in a broad range of impacts on both human and ecosystems including economic losses, impacts on different sectors such as tourism and agriculture, on urban settlements and on access to water. The severity of these impacts will depend strongly on the level of exposure and vulnerability to climate extremes. Collectively these impacts can also have a significant adverse affect on the population and can harm national, regional and global development. A sample of impacts can be found below.

3.1 Increasing economic losses[24]

There is *high confidence* that economic losses from weather and climate related disasters are increasing, albeit with large inter-annual variability. Increasing exposure of people and economic assets has been a major cause. Whilst measured economic losses from disasters are largest in developed countries, there is high confidence that fatality rates and economic losses as a proportion of GDP are higher in developing countries. The largest absolute adaptation costs are expected in East Asia and the Pacific, followed by Latin American and the Caribbean as well as sub-Saharan Africa.

Increasing drought risk may cause a decline in tourism, fisheries, and cropping. This could reduce the revenue available to governments, enterprises, and individuals, and hence further deteriorate the capacity for investment in climate change adaptation and disaster risk reduction. Climate extremes exert a significant control on the day-to-day economic development of Africa, particularly in the areas of traditional rain-fed agriculture and pastoralism, and water resources, at all scales. For example, Cameroon's economy is highly dependent on rain-fed agriculture; a 14% reduction in rainfall is projected to cause losses of around US$4.65 billion.

Although Africa accounted for only 0.6% of global economic losses, drought events in particular are under-reported compared to other regions. Many impacts, such as loss of human lives, cultural heritage, and ecosystem services, are also difficult to measure as they are not normally given monetary values or bought and sold, and thus are poorly reflected in estimates of losses. Impacts on the informal or undocumented economy may be very important in some areas and sectors, but are generally not counted. Increasing drought risk may cause a decline in tourism, fisheries, and cropping. This could reduce the revenue available to governments, enterprises, and individuals, and further deteriorate the capacity for risk reduction investment. For example, the 2003-2004 drought cost the Namibian Government N$275 million (US$43-48 million) in provision of emergency relief.

3.2 Sector vulnerability[25]

Extreme events have the greatest impacts on sectors that are closely linked with or dependent on the climate, for example water, agriculture and food security, forestry, health and tourism. There is high confidence that changes in the climate could seriously affect water management systems. Climate extremes also have large adverse impacts on infrastructure e.g. roads cracking, railways buckling, and flooding of airports, particularly in coastal areas. Coastal inundation due to storm surges and floods can affect terminals, freight villages, storage areas, and cargo, and disrupt supply chains and transport. This may have far reaching implications for international trade, as more than 80% of global trade in goods (by volume) is carried by sea. The tourism sector is also sensitive to the climate; particularly given that climate is a key factor in tourism demand.

Agriculture is affected directly by both temperature extremes and rainfall, and is the economic sector most vulnerable and exposed to climate extremes in Africa. It

24. Draws on materials from SREX Chapter 4, Handmer, J. et al, 'Changes in Impacts of Climate Extremes: Human Systems and Ecosystems', and SREX Chapter 6, Lal, P. N. et al, 'National Systems for Managing the Risks from Climate Extremes and Disasters'.
25. Draws on materials from SREX Chapter 4, Handmer, J. et al, 'Changes in Impacts of Climate Extremes: Human Systems and Ecosystems'.

contributes approximately 50% to Africa's total export value and approximately 21% of its total GDP. Climate impacts in Namibia for example, could cause annual losses of 1 to 6% of GDP, from which livestock production, traditional agriculture, and fishing are expected to be hardest hit, with a combined loss of US$461-2,045 million per year by 2050.

Other short-term but limited strategies to minimise **food security** risks include diversifying livelihoods, farming in different ecological niches, building social networks, establishing safety net and social protection schemes and risk-pooling at regional or national level to reduce financial exposure. Longer-term strategies include land rehabilitation, terracing and reforestation, measures to enhance water catchment and irrigation techniques, improvements to infrastructure quality for better access to markets and the introduction of drought-resistant crops.

The future reliability of small-scale rural **water** sources in Africa is largely determined by local demands, water quality or access constraints. 25% of the contemporary African population has limited water availability whereas 69% of the population experiences relative water abundance. However, for this latter group, relative abundance does not necessarily mean access to safe drinking water and sanitation, and this negatively affects human vulnerability. Only about 62% of the African population had access to improved water supplies in 2000. As many as 90 million people in low rainfall areas (200-500mm) would be at risk if rainfall reduces to the point at which groundwater resources become non-renewable. Natural water reservoirs such as lakes already experience marked inter-annual water level fluctuations related to rainfall variability. Since the early 1980s there is a decreasing trend in many water lake levels, for example in lakes Tanganyika, Victoria and Turkana.

Health impacts include direct death and injury due to e.g. flooding, together with infectious diseases and malnutrition and a shift in malaria epidemic regions by changing breeding sites for mosquitoes. For example, In the arid and semi-arid areas of countries of the Horn of Africa, extreme rainfall events are often associated with a higher risk of diseases such as malaria, dengue fever, cholera, Rift Valley fever (RVF), and hantavirus pulmonary syndrome. Recent studies in Mozambique demonstrate how extensive (low impact/high frequency) disasters negatively affect children's education, health and access to services such as water and sanitation. Indirect health impacts (including stress, anxiety, mental illness, increased susceptibility to infection, and disruption of socio-economic structures and food production that may lead to malnutrition months after an event) are therefore a potentially large but under-examined outcome of extreme weather events that lead to a substantial underestimation of the total health burden.

3.3 Urban settlements[26]

Changes in settlement patterns, urbanisation, and changes in socio-economic status in Africa have influenced observed trends in vulnerability and exposure to climate extremes. In many coastal areas growing urban settlements have also affected the ability of natural coastal systems to respond effectively to extreme climate events, thus rendering them more vulnerable. Most of Africa's largest cities are on the coast and have large sections of their population at risk from flooding. Compared to Asia, Europe and the Americas, a greater percentage of Africa's population lives in coastal cities of 100,000 to five million people, many of which tend to be poor and growing at much higher rates than cities in the other continents. Flooding regularly disrupts cities and urban food production, which can undermine food security, particularly in poor communities. Heavy rainfall and flooding can also contaminate surface water and affect environmental health in urban areas. Urban poor populations in low- and middle-income countries can experience higher rates of infectious disease after floods, such as cholera, cryptosporidiosis, and typhoid fever.

Damage to African port cities from flooding, storm surge, and high winds might increase due to climate change. In Alexandria, US$563.28 billion worth of assets could be damaged or lost due to coastal flooding alone by 2070. Flooding also regularly disrupts cities and urban food production, which can undermine food security, particularly in poor communities. Furthermore, heavy rainfall and flooding contaminate surface water and affect environmental health in urban areas, especially as most urban centers in sub-Saharan Africa have no sewers.

The amount of vulnerability concentrated within these cities will define their risks, and in the absence of adaptation there is high confidence that locations currently experiencing adverse effects, such as coastal erosion and inundation, will continue to do so in the future. However, there is a certain limit to adaptation given that these cities are fixed in place and some degree of exposure to hazards is 'locked in' due to the unlikelihood of relocation.

26. Draws on materials from SREX Chapter 4, Handmer, J. et al, 'Changes in Impacts of Climate Extremes: Human Systems and Ecosystems'.

4. Managing the risks of climate extremes and disasters

This section considers the ranges of responses required in order to try to better manage the risks of climate extremes and disasters. It considers the key messages 6-10 in more detail (see section 1.2).

Managing the risk at different scales/levels[27]

Disaster risk will continue to increase in many countries as more vulnerable people and assets are exposed to climate extremes. Increases in the occurrence of such weather-related disaster risk will magnify the uneven distribution of risk between wealthier and poorer countries. Climate change is altering the geographical distribution, intensity and frequency of some weather-related hazards in some regions, which threatens to exceed the capacities of poorer countries to absorb losses and recover from disaster impacts. So risk management becomes critical. This section considers the risk management options at local, national and international levels.

Closer integration of disaster risk management and climate change adaptation, along with the incorporation of both into local, sub-national, national, and international development policies and practices, could provide benefits at all scales. Addressing social welfare, quality of life, infrastructure, and livelihoods, and incorporating a multi-hazards approach into planning and action for disasters in the short term, facilitates adaptation to climate extremes in the longer term. When considering the linkages between disaster management, climate change adaptation and development, timescales play an important role. For example, during disaster reconstruction tensions frequently arise between demands for speed of delivery and sustainability of outcome. Response and reconstruction funds tend to be time limited, often requiring expenditure within 12 months or less from the point of disbursement. This pressure is compounded by multiple agencies working with often limited coordination. Time pressure and competition between agencies tends to promote centralised decision-making and the sub-contracting of purchasing and project management to non-local commercial actors. Both outcomes save time but miss opportunities to include local people in decision-making and learning from the event, with the resulting reconstruction in danger of failing to support local cultural and economic priorities. Strategies and policies are more effective when they acknowledge multiple stressors, different prioritised values, and competing policy goals.

4.1 Local level DRM[28]

Integrating local knowledge with additional scientific and technical knowledge can improve disaster risk reduction and management and adaptation. This self-generated knowledge can uncover existing capacity, as well as important shortcomings. The social organisation of societies dictates the flexibility in the choice of protective actions.

A lack of access to information by local people has restricted improvements in the knowledge, understanding, and skills needed to help localities to protect themselves against disasters and climate change impacts. The information gap is particularly evident in many developing countries with limited capacity to collect, analyze and use scientific data on demographic trends, as well as evolving environmental conditions. Closing this gap is critical to reducing climate related threats to rural livelihoods and food security in Africa. Where local leadership is determined, effective planning is possible, even without legislation. This has been the experience of farmers in the Northern Cape, South Africa, as outlined in Box 3.

Box 3: Small-scale farmers adapting to climate change in Northern Cape Province

This Province has a harsh landscape, with frequent and severe droughts and extreme conditions which have impacted negatively on small-scale rooibos farmers. In 2001 a small group of farmers founded the Heiveld Co-operative Ltd to take collaborative action to improve their livelihoods. Following a severe drought (2003-2005) and a perceived increase in weather variability, the co-op decided to monitor the local climate and to run climate change preparedness workshops, supported by climate scientists. The Heiveld became a repository and source of local and scientific knowledge related to sustainable rooibos production. The co-operative has since focused on supporting the development of adaptation strategies through a joint learning approach to respond to and prepare for climate change.

27. Draws on materials from SREX Chapter 8, O'Brien, K. et al, 'Toward a Sustainable and Resilient Future'.
28. Draws on materials from SREX Chapter 5, Cutter, S. et al, 'Managing the Risks from Climate Extremes at the Local Level'.

It is important to overcome the disconnect that remains between local risk management and national institutional and legal policy and planning. Local level DRM for example can, and should, be supported by environmental planning, urban land use planning, livelihood strengthening and improvement in health surveillance, water supply, sanitation, and irrigation and drainage systems. A study of four countries, including two from Africa (Mozambique and South Africa), found that effective local DRM can be constrained by the factors identified in Box 4.

Box 4: Constraints to effective local DRM

a) **Low capacity for implementation at local level.**

b) **Funds dedicated to DRM often being channelled elsewhere.**

c) **The fact that decentralisation does not automatically lead to more inclusive decision-making processes.**

d) **An appreciation that decentralised systems face significant communications challenges across levels.**

e) **Knowledge that robust measures for ensuring accountability and transparency are vital for effective disaster risk management, but are often missing.[29]**

4.2 National level DRM[30]

National systems are at the core of countries' capacity to meet climate challenges. Effective national systems comprise multiple actors from national and sub-national governments, the private sector, research bodies and civil society, including Community-Based Organisations (CBOs), each playing differential but complementary roles to manage risk according to their accepted functions and capacities. Greater efforts are required to address the underlying drivers of risk and generate political will to invest in disaster risk reduction. Changes in weather and climate extremes also pose new challenges for national DRM systems, which are often poorly adapted to current risks. However, there are relatively few examples where mainstreaming adaptation to climate change and DRM issues have been priorities over extended periods of time and have made significant progress, e.g. South Africa's Disaster Management Act and its National Disaster Management Policy Framework. A recently developed index that measures capacities and conditions for risk reduction shows that low and lower-middle-income countries with weak governance tend to have great difficulty addressing underlying drivers of vulnerability. Those at the bottom of the index, e.g. Chad, also face conflict or political instability. Legislation at the national level can play a useful role as a driver for change as explored in Box 5.

Box 5: Kenya's National Climate Change Platform

This Platform sits in the Office of the President and has made significant achievements in coordinating multiple stakeholders. However, it is constrained by limited resources and lack of DRR budgets in line ministries. Difficulties have therefore arisen in integrating DRR in planning processes in urban and rural areas and a lack of data on risks and vulnerabilities at different scales has been noted.

In Nairobi increasing exposure and vulnerability has resulted from a rapid expansion of poor people living in informal settlements, with poorly built houses constructed adjacent to rivers and blocking natural drainage areas. While data and co-ordination systems are still lacking, the Government has established the Nairobi Rivers Rehabilitation and Restoration Programme, designed to install buffers, canals and drainage channels, while also clearing existing channels to reduce flood risks. The Programme targets the urban poor with improved water and sanitation, paying attention to climate variability and environment monitoring for flood early warning.

The government is developing a national disaster management policy. This will build resilience to hazard events, strengthen institutional capacity, develop a well-managed disaster response system, reduce vulnerability and integrate disaster policy with development policy taking a multi-sectoral, multi-level approach. The draft policy published in 2009 sets out principles for effective disaster management, codes of conduct for stakeholders, and provides for the establishment of an institutional framework that is legally recognised and embedded within government structures. It also stresses the importance of mobilising resources to enable implementation of the policy, with provision of 2% of the annual public budget to a National Disaster Management Fund. In 2010 this policy had not reached Parliament for discussion and approval.

29. Scott and Tarazona, 2011
30. Draws on materials from Chapter 6, Lal, P. N. et al, 'National Systems for Managing the Risks from Climate Extremes and Disasters'.

A number of countries in Africa lack many of the institutional mechanisms and legal frameworks important for coordination at national level. Without a supporting and implemented national legislative structure, achieving local DRR and climate change adaptation planning can be complicated. In some high-risk regions rapid development of national platforms of CSOs and Community-Based Organisations (CBOs) is helping to push for the transformation of policies and practices related to DRR.

Public understanding of risks and vulnerabilities is critical, but insufficient for risk management; early warning systems therefore need to be complemented by preparedness programmes as well as public education and awareness. This requires systematic linkages and integration between early warning systems and contingency planning processes. An example of the need for such warning systems in highlighted in Box 6.

A set of factors has been identified that make efforts to systematically manage disaster risk more successful. These are captured in Box 7.

A closer look at South Africa's legislation model, which incorporates several of these factors, can be found in Box 8. The legislation focuses on prevention, decentralises DRR governance, mandates the integration of DRR into development planning, and requires stakeholder inclusiveness. It makes a legal connection between DRR and development planning. Other African countries adopting this approach include Comoros, Djibouti, Ethiopia, Ivory Coast, Mauritius, and Uganda.

Box 7: Factors for more successful management of disaster risk[31]

- **Risks are recognised as dynamic and risk management is therefore mainstreamed and integrated into policy and strategy. South Africa's disaster risk management legislation for example, decentralises DRR governance and mandates the integration of DRR into development planning.**
- **Legislation for managing disaster risk is supported by clear regulation that is enforced, for example there is a need to reinforce municipal laws on planning and urban design in Accra, Ghana.**
- **Disaster risk management functions are co-ordinated across sectors and scales and led by organisations at the highest political level. In Kenya for example, the National Platform for climate change is situated under the Office of the President.**
- **Risk is quantified and factored into national budgetary processes. The government of Kenya intends to allocate 2% of the annual public budget to a National Disaster Management Fund.**
- **Decisions are informed by the right information, using a range of tools and guidelines. In South Africa for example, climate scientists are supporting local tea farmers to develop climate preparedness strategies.**
- **Early warning systems work, for example in Mozambique early warning systems have helped to reduce the impact of cyclones and flooding since 2007.**

Box 6: Cholera in Zimbabwe

The 2008 cholera epidemic was the worst the world had seen in two decades, affecting approximately 100,000 people and killing over 4,500. Contamination of drinking water sources was almost certainly amplified by the onset of the rainy season. In addition to its size, this epidemic was distinguished by its urban focus and relatively high fatality rate. Managing the risk of climate-sensitive disease will necessarily become more iterative and adaptive as climate change shifts the hazard landscape and heightens vulnerability in certain populations. Without losing the focus on containment, institutional learning could incorporate strategies to address root causes, reducing the likelihood of future outbreaks. In the case of cholera, such exploration has opened the possibility of devising warning systems and other risk management strategies. The processes of Disaster Risk Management and preventive public health are also closely linked, and largely synonymous. Strengthening and integrating these measures, alongside economic development, should increase resilience against the health effects of extreme weather.

Box 8: Legislation for multilevel governance of DRR and adaptation

The South African government passed three disaster management bills that culminated in the promulgation of the Disaster Management Act of 2002 and of the National Disaster Management Framework in 2005. These define the institutional structure that governs DRR at national, provincial and municipal levels. The forums established by the Act give voice to additional stakeholders to participate in DRR decision-making. Implementation of these benchmark legislative provisions has proven challenging. Many district municipalities have not yet established the disaster management centres required by the Act and the majority of local municipalities have not yet established advisory forums. Similarly, interdepartmental committees, which facilitate collaboration and the integration of DRR into development planning, have also not yet been established in a majority of municipalities. Not all relevant national departments have undertaken required DRR activities or identified sectoral focal points. Implementation may be hindered by the placement of the National Disaster Management Centre within a line ministry (Department of Cooperative Governance). Positioning DRR institutions within the highest levels of government has proven effective because this position often determines the amount of political authority of the national disaster risk management body.

The main lesson is that carefully crafted legislation buttresses DRR activities, thus avoiding a gap between the law's vision and its implementation. The institutional arrangements provide both access to power for facilitating implementation and opportunities to 'mainstream' DRR and adaptation into development plans. The law includes provisions that increase accountability and enable coordination and implementation.

31. Draws on material from Chapter 8, O'Brien, K. et al, 'Toward a Sustainable and Resilient Future'.

4.3 Risk management at the international level[32]

International actors can also play a useful enabling role in risk management and promoting climate resilience as summarised in Box 9.

International funding mechanisms such as the LDC (Least Developed Countries) Fund, the Special Climate Change Fund, the Multi-donor Trust Fund (MDTF) on Climate Change, and the Pilot Programme for Climate Resilience (PPCR) under the Climate Investment Fund (CIF) are making funding and resources available to developing countries to pilot and mainstream climate risk management and resilience building into development. This provides incentive for scaled-up action and transformational change, although funding is inadequate.

In Africa the potential additional costs of adaptation range from US$3-10 billion per year by 2030. However, this could be underestimated, considering the desirability of improving Africa's resilience to climate extremes as well as the flows of international humanitarian aid in the aftermath of disasters. Funding will need to come from a wide variety of sources, public and private, bilateral and multilateral, including alternative sources of finance, the scaling up of existing sources, and increased private flows. Grants and highly concessional loans are crucial for adaptation in the most vulnerable developing countries, including in Africa.

Risk transfer (usually with payment) and risk sharing (usually informal, with no payment) mechanisms are also recognised by international actors as an integral part of DRM and adaptation. A number of international organisations are already supporting countries most at risk from climate impacts to explore the potential for risk transfer, for example through enabling access to insurance against extreme weather events. The international transfer and sharing of risk is an opportunity for individuals and governments of all countries that cannot sufficiently diversify their portfolio of weather risk internally, and especially for governments of vulnerable countries that do not wish to rely on ad hoc and often insufficient post-disaster assistance. Some specific examples of risk transfer in Africa are illustrated in Box 10.

Box 9: The role of IFIs, donors and other international actors in risk management

International agencies can play a strongly catalytic role in risk management and climate resilience most notably by:

- **exercising convening power and coordinating initiatives**
- **supporting public goods for development of risk market infrastructure**
- **providing technical assistance and sharing experience**
- **creating enabling markets, for example in the banking sector**
- **financing risk transfer, for example through micro-insurance.**

Box 10: Risk transfer examples

The World Food Programme (WFP) in Ethiopia – development of insurance using an index

The WFP began supporting the Ethiopian government-sponsored Productive Safety Net Programme (PSNP)[33] in 2006. WFP is now providing insurance to the government against extreme drought so that when there is a food emergency, the PSNP is able to provide immediate cash payments that may save lives. However, these payments may not be sufficient to restore livelihoods. A drawback, in contrast to the micro-insurance programs in Malawi, is that it perpetuates dependence on post-drought government assistance, with accompanying moral hazard. (i.e. a tendency to take undue risks because the costs are not borne by the party taking the risks). While this transaction relied on traditional re-insurance instruments, there is current interest in issuing a CAT bond[34] for this same purpose.

Micro-insurance in Malawi

In Malawi the World Bank and WFP provided essential technical assistance and support for establishing a pilot micro-insurance programme to provide index-based drought insurance to smallholder farmers. These transactions set innovative and promising precedents in terms of protecting highly exposed developing and transition government portfolios against the risks imposed by disasters.

32. Draws on materials from Chapter 7, Burton, I. et al, 'Managing the Risks: International Level and Integration Across Scales'.
33. The Productive Safety Net Programme (PSNP) was implemented in Ethiopia in 2007 in response to experiences from a series of drought-related disaster responses during the late 1990s and early 2000s (Pierro and Desai, 2008; Conway and Schipper, 2011). The aim of the Programme was to shift institutional approaches away from just emergency responses and into more sustainable livelihood approaches involving asset protection and food security. Under this Programme, millions of people in 'chronically' food insecure households in rural Ethiopia received resources from the PSNP through cash transfers or food payments for their participation in labour intensive public works projects with a particular focus on environmental rehabilitation (Conway and Schipper, 2011).
34. A Catastrophe Bond is a risk linked security that transfers a specified set of risks from a spnsor to investors.

5. Conclusions: What does this mean for decision makers in Africa?[35]

This final section considers the implications for Africa in more detail. As climate change impacts become more dramatic, the effects on a range of climate extremes will become more important and will play a more significant role in disaster impacts and DRM. The capacity of African countries to meet this challenge will be determined by the effectiveness of their national risk management systems, including adaptation and mitigation measures. Some are poorly prepared and need to reassess their vulnerability, exposure and investments in order to better manage disaster risks. A new balance needs to be struck between measures to reduce and transfer risk, and to effectively prepare for and manage disaster impacts in a changing climate.

5.1 Links to the mitigation of greenhouse gases

Rapid and comprehensive reduction of greenhouse gas emissions is required in order to reduce the need for future adaptation and DRM in the longer term. Creating synergies between adaptation and mitigation can increase the cost-effectiveness of action and make them more attractive to stakeholders including potential funding agencies. Opportunities for synergies are greater in some sectors (agriculture and forestry, buildings and urban infrastructure) but are more limited in others (coastal systems, energy and health). Examples include where adaptation leads to effects on mitigation such as watershed planning including hydro-electricity affecting greenhouse gas emissions, or where mitigation can affect capacity to adapt, such as community carbon sequestration affecting livelihoods.[36]

5.2 Coping, adapting and learning

How well a community responds to and survives disaster depends upon the resources that can be used to cope. Adaptation in anticipation of extreme events can help to limit the 'coping' that may be required to survive the next disaster. Adaptive capacity focuses on longer-term and more sustained adjustments, e.g. better rainwater harvesting techniques, changing crops, or building further inland or on higher ground. As possible climate futures are uncertain, 'no regrets' adaptation strategies are often recommended. They have net benefits over the range of anticipated future climate and associated impacts. Learning is essential to risk management and adaptation. Research on learning emphasises the importance of action-oriented problem solving, learning-by-doing, and concrete learning cycles. Box 11 reviews how learning from Mozambique's flood in 2000 was applied in 2007.

While urban areas have expanded in size and influence, the majority of poor people in Africa continue to reside in rural areas and are amongst the most resource-scarce and capacity-limited population group. Even small increases in the frequency or severity of hazards can cause local livelihoods to collapse, though recent developments in communication technology may help to bridge this gap.

Box 11: A comparison of the flood response in Mozambique in 2000 and 2007

In February 2000 floods killed more than 700 people, over half a million people lost their homes, and more than 4.5 million people were affected. These losses were associated with institutional, technical and financial problems. For example, the National Policy on Disaster Management only began to shift from a reactive to a proactive, prevention-focused approach in 1999. After 2000 the Government improved the effectiveness of disaster risk management. In 2006 the government adopted a comprehensive strategy for dealing with vulnerability to natural disasters.

In 2007 when flooding occurred the country was much better prepared. 29 people were killed, 140,000 displaced, and 285,000 people affected. Approximately 12,800 people at risk from rising river levels had been prepared by training. The district's disaster mitigation committee had alerted threatened villages two days previously (blue-flag alert) and later a red-flag alert announced evacuations, which were completed in less than two days. Approximately 2,500 people were moved to accommodation centres.

35. Draws on materials from SREX Chapter 6, Lal, P. N. et al, 'National Systems for Managing the Risks from Climate Extremes and Disasters' and Chapter 8, O'Brien, K. et al, 'Toward a Sustainable and Resilient Future'.
36. These examples are from WGII, chapter 18 of the IPCC Fourth Assessment Report.

5.3 Integrating DRM, climate change adaptation and sustainable development

Sustainable development involves finding pathways that achieve a variety of socioeconomic and environmental goals, without sacrificing any one for the sake of the others. As a result, the relationships between adaptation, disaster risk management and sustainability are highly political. Successful reconciliation of multiple goals 'lies in answers to questions such as who is in control, who sets agendas, who allocates resources, who mediates disputes, and who sets rules of the game'.[37] This means that conflicts of interest must be acknowledged and addressed, whether they are between government departments, sectors, or policy arenas, and suggests that simple panaceas are unlikely without trade-offs in decision-making. The effectiveness of actions to reduce, transfer, and respond to current levels of disaster risk could be vastly increased. Exploiting potential synergies between DRM and adaptation to climate change will improve management of both current and future risks, and strengthen adaptation processes.
Disaster risk management and adaptation to climate change literatures both now emphasise bottom up, grass roots approaches, as well as the value of more holistic, integrated approaches. There are many potential synergies between DRM and climate change adaptation that can contribute to a sustainable and resilient future.

There is a need for mainstreaming adaptation into existing national policies and plans, and for capitalising on options that take advantage of synergies with other national objectives. Studies found that many strategies and institutions were focused to a greater extent on lower-risk actions dealing with science and outreach (knowledge acquisition) and capacity-building rather than on specific, more costly and difficult to implement adaptation and disaster risk management actions.

Although there is no single approach, framework or pathway to achieve such an integrated approach some important contributing factors have been identified. These include reducing exposure, reducing vulnerability, transferring and sharing risks and adequate preparation, response and recovery. These are captured in Figure 4.

Figure 4: Integrating adaptation and DRM approaches for a changing climate[38]

RISKS ACCEPTANCE THRESHOLD

REDUCE RISKS

REDUCE VULNERABILITY
- Poverty reduction
- Health improvements
- Access to services and productive assets enhanced
- Livelihood diversification
- Access to decision-making increased
- Community security improved

REDUCE HAZARDS AND EXPOSURE
- Mainstream risk management into development processes
- Building codes and retrofitting
- Defensive infrastructure and environmental buffers
- Land use planning
- Catchment and other ecosystem management
- Incentive mechanisms for individual actions to reduce exposure

POOL, TRANSFER, AND SHARE RISKS
- Mutual and reserve funds
- Financial insurance
- Social networks and social capital
- Alternative forms of risk transfer

MANAGE RESIDUAL RISKS AND UNCERTAINTIES

PREPARE AND RESPOND EFFECTIVELY
- Early warning and communication
- Evacuation plan
- Humanitarian: relief supplies
- Post-disaster livelihood support and recovery

INCREASE CAPACITY TO COPE WITH 'SURPRISES'
- Flexibility in decision-making
- Adaptive learning and management
- Improved knowledge and skills
- Systems transformation over time

37. Wilbanks, 1994: 544.
38. Lal, P.N., T. Mitchell, P. Aldunce, H. Auld, R. Mechler, A. Miyan, L.E. Romano, and S. Zakaria, 2012: National systems for managing the risks from climate extremes and disasters. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 339-392.

A further set of critical factors to successfully integrate DRM, climate adaptation and resilience building have also been identified and are highlighted in Box 12.

Box 12: Eight critical factors for integrating DRM, Climate Adaptation, and Resilience Building

1. **The capacity to reconcile short-term and long-term goals.**
2. **The willingness to reconcile diverse expressions of risk in multi-hazard and multi-stressor contexts.**
3. **The integration of DRM and climate change adaptation into other social and economic policy processes.**
4. **Innovative, reflexive, and transformative leaders (at all levels).**
5. **Adaptive, responsive, and accountable governance.**
6. **Support for flexibility, innovation and learning, locally and across sectors.**
7. **The ability to identify and address the root causes of vulnerability.**
8. **Long-term commitment to managing risk and uncertainty and promoting risk-based thinking.**

5.4 Building long-term resilience: from incremental to transformational[39]

If extreme climate and weather events increase significantly in coming decades, climate change adaptation and DRM are likely to require not only *incremental (small, within existing technology and governance systems)* changes, but also *transformative (large, new system)* changes in processes and institutions. This will involve moving away from a focus on issues and events towards a change in culture and overall approach, elaborated in the following areas:

Partnerships: among the most successful DRM and adaptation efforts are those that have facilitated the development of partnerships between local leaders and other stakeholders, including extra-local governments. This allows local strengths and priorities to surface, while acknowledging that communities and local governments have limited resources and strategic scope to address the underlying drivers of risk on their own.

Leadership can be critical for DRM and climate change adaptation, particularly in initiating processes and sustaining them over time. Change processes are shaped by the action of individual champions (including those resisting change) and their interactions with organisations, institutional structures and systems. Leadership can be a driver of change, providing direction and motivating others to follow. A number of private sector organisations have demonstrated this at Chair and CEO level enabling transformational change within their organisations.

Identifying the drivers of hazard and vulnerability in ways that empower all stakeholders to take action is key. This is done best where local and scientific knowledge is combined in the generation of risk maps or risk management plans. Greater use of local knowledge and local capacity can initiate enhanced accountability in integrated risk decision-making. There is also need for better co-ordination and accountability within governance hierarchies and across sectors.

International actors can help by providing an institutional framework to support experimentation, innovation and flexibility, financing risk transfer and supporting funding for adaptation.

Technology is an essential part of responses to climate extremes, at least partly because technology choices and uses are so often a part of the problem. Enhancing early warning systems is one example where technology can play an important role in DRM, particularly in considering 'hard' (engineering) and 'soft' (social and administrative) technology. Although technology is an essential part of our response to climate change, responses can also be improved by addressing social vulnerability, rather than focusing exclusively on technological approaches.

Transformation can imply loss of the familiar, creating a sense of disequilibrium and uncertainty. Desirable or not, transformations are occurring at an unprecedented rate and scale, influenced by globalisation, social and technological development, and environmental change. Climate change itself represents a system-scale transformation that will have widespread consequences on ecology and society, including through changes in climate extremes.

Responses to climate change and changes in disaster risk can be both incremental and transformational. Transformation calls for leadership, both from authority figures who hold positions and power, and from individuals and groups who connect present-day actions with building a sustainable and resilient future.

For further information

The Summary for Policy Makers, full report, fact sheet and video is available at: http://ipcc-wg2.gov/srex.

Other useful links including videos and recommended reading are on the CDKN website here: www.cdkn.org/srex.

39. Draws on materials from Chapter 5, Cutter, S. et al, 'Managing the Risks from Climate Extremes at the Local Level', Chapter 6, Lal, P. N. et al, 'National Systems for Managing the Risks from Climate Extremes and Disasters', and Chapter 7, Burton, I. et al, 'Managing the Risks: International Level and Integration Across Scales'.

IPCC SREX Glossary of Terms

Core concepts defined in the SREX and used throughout the summary include:

Climate Change: A change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Climate Extreme (extreme weather or climate event): The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes.' The full definition is provided in Section 3.1.2 of the SREX report.

Exposure: The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected.

Vulnerability: The propensity or predisposition to be adversely affected.

Disaster: Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Disaster Risk: The likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Disaster Risk Management: Processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, resilience, and sustainable development.

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

Transformation: The altering of fundamental attributes of a system (including value systems; regulatory, legislative, or bureaucratic regimes; financial institutions; and technological or biological systems).

IPCC Uncertainty Guidance

The standard terms used to define levels of confidence in this report are as given in the IPCC Uncertainty Guidance Note, namely:

Confidence terminology	Degree of confidence in being correct
Very high confidence	At least 9 out of 10 chance
High confidence	About 8 out of 10 chance
Medium confidence	About 5 out of 10 chance
Low confidence	About 2 out of 10 chance
Very low confidence	Less than 1 out of 10 chance

The standard terms used in this report to define the likelihood of an outcome or result where this can be estimated probabilistically are:

Likelihood terminology	Likelihood of the occurrence/outcome
Virtually certain	> 99% probability
Extremely likely	> 95% probability
Very likely	> 90% probability
Likely	> 66% probability
More likely than not	> 50% probability
About as likely as not	33 to 66% probability
Unlikely	< 33% probability
Very unlikely	< 10% probability
Extremely unlikely	< 5% probability
Exceptionally unlikely	< 1% probability

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