FINAL REPORT:

Science for Humanitarian Emergencies and Resilience (SHEAR) Scoping Study

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Report summary

This scoping study was prepared to provide evidence in support of the Science for Humanitarian Emergencies and Resilience (SHEAR) research programme on risk assessments and early warning systems. The main focus of the programme is on weather-related hazards (e.g. cyclones, floods, droughts, landslides) for humanitarian and development purposes in low-income countries across Africa, the Caribbean and South Asia. The study was based on:

- Stakeholder surveys aimed at practitioners, and researchers, working in the three regions
- A UK workshop together a series of small international meetings and a number of one-to-one interviews
- A comprehensive literature review
- A number of case studies on community based risk assessment and early warning systems
- A desk study on relevant initiatives, gaps and needs in the Caribbean

This report is accompanied by six standalone Annexes as follows[1]:

- Annex 1 - Results of a stakeholder survey
- Annex 2 - Literature review
- Annex 3 - Community-based case studies covering the three regions
- Annex 4 - Current initiatives and research priorities in the Caribbean
- Annex 5 – Workshop report, London 9 December 2013. This was attended by approximately 40 UK-based researchers and some users of information
- Annex 6 - Notes from a Caribbean workshop and stakeholder engagement
- Annex 7 – Notes from a workshop and relevant meetings attended in Kenya

The study identified a number of barriers to improving risk assessments and early warning systems for weather-related hazards:

- Availability of suitably disaggregated data on vulnerability and exposure of people and the potential damage to key at-risk assets coupled with a lack of support of local data collection that is sustainable and legitimate
- Accessibility of risk maps, and their relevance to humanitarian and development goals
- Availability of accurate spatial information, such as elevation data for flood risk analysis or simply the location of people, livestock and properties
- Lack of technical capacity to produce maps or appropriate information products to reach the people that need this information
- Lack of community participation that is effectively joined up to wider risk assessments and early warning systems
- Lack of visibility and accountability of extensive risks i.e. risks from weather-related hazards whose consequences are too small to be classified as major disasters
- The lack of suitable methodologies to assess cascading hazards and multi-hazards risk assessments in low income countries
- The accessibility to Information and Communication Technology (ICT)
- The effectiveness of the communication of warnings and risk

[1] Annexes are available from the Evidence on Demand online document library.

- Lack of capacity and funding for risk assessments and early warning systems
- Ineffective coordination especially where natural hazards cross-boundaries, for example in international river basins
- A lack of monitoring and evaluation of early warning systems
- Availability of appropriate data and monitoring systems including the poor coverage of hydro-meteorological networks

The Table below provides an overview of the weather-related hazards for each of the three regions where further research is required. The prioritisation of the hazards was based on the following:

- The humanitarian impact of the hazard in terms of the total number of people affected.
- The effectiveness of the risk assessments and early warning systems that have been implemented previously

An overview of the weather-related hazards for each of the three regions for which further research is required

Research priority	Africa	The Caribbean	South Asia
Highest	Droughts	Floods	Droughts
	Floods	Droughts	Landslides
	Cyclones	Landslides	Floods
Lowest	Landslides	Cyclones	Cyclones

This report focused on these major hazards; however, a few stakeholders also raised other weather related hazards that are also important and may warrant further research including fire, heat-waves, air pollution episodes, vector and water borne diseases and Glacial Lake Outburst Floods. In addition the adoption of multi-hazard approaches was promoted by many users.

Although in South Asia cyclones and floods have a large humanitarian and economic impact there is evidence to suggest that the research that has already been undertaken has been effective in reducing both loss of life and economic impacts. In South Asia the research on both risk assessments and early warning systems for landslides is limited although in countries like Nepal the number of fatalities as a result of this hazard has been significant and they also have an effect on people's livelihoods through a loss of livestock and farmland.

In the Caribbean significant progress has been made in reducing the humanitarian impacts of cyclones. Relatively speaking there has been much less research carried out on floods and droughts in the Caribbean than for cyclones, despite the fact the impacts of these are significant,

The Table below provides a summary of the priority research goals and their potential impacts.

Table A summary of priority research goals and potential impacts

Research goals	Potential research impacts
Insight to overcome governance and management challenges	• An understanding how institutional factors influence risk assessment and the effectiveness of early warning systems • Recommendations for capacity building • Improving the links between early warnings and early actions • Providing guidance on effective risk assessments and early

Research goals	Potential research impacts
	warning systems for conflict situations • Improved trans-boundary cooperation with respect to early warning systems
Better monitoring and evaluation of early warnings and risk assessments	• Improved understanding of effectiveness, what works and what does not work • A method to provide accountability that will enable improvements to be made • Protocols, monitoring and evaluation frameworks, learning • Improvements to systems, increasing effectiveness and reducing loss of life
Understanding of issues related to people with disabilities and the most vulnerable in society	• Recognition of this issue in policy and governance mechanisms, as well as emergency plans for a range of hazards.
Methods for effective use of low-cost sources of information (e.g. 'crowd sourced' data using mobile phones) on hazard, vulnerability, exposure and loss	• Improved access of a range stakeholders to information on risk as well as early warnings of weather-related hazards • Innovation and the use of risk and early warning products • Improved collection of disaggregated vulnerability data and its assessment • Improved collection of disaggregated damage and loss data and its assessment • Integration of disaster risk reduction and development from disaggregated data collection to policy integration • Development of protocols to deliver sustainable, low cost data sets on vulnerability, exposure and loss for vulnerable communities and key assets (e.g. water supply and sanitation, health and education infrastructure)
Improvements in climate modelling	• Improved monitoring to support local risk assessments and improved climate models • Increased skill that results • Earlier warnings that have a greater degree of confidence • Improvements in downscaling that provide beneficiaries such as farmers with information that is more useful to them • Improvements in intra-seasonal predictability (e.g. the distribution of rainfall throughout the growing season)
Improved flood risk assessment and early warning of floods	• Regional flood hazard and flood risk maps • Improved estimates of flood risk and assessments of loss and damage • Recognition of how short and medium scale forecasting could improve emergency planning. • Development of information products and processes for dissemination. • Use of medium term and seasonal forecasts for planning humanitarian responses, e.g. ensuring timely mobilisation.
Use of remote sensing data in improving early warning systems and real-time risk assessments	• Improved awareness and capacity for using remotely sensed products in risk assessments and early warning systems. • Design of new data products that incorporate ground based observations and remotely sensed data. • Guidance on designing ground observation monitoring systems.
Modelling of the risks from multi-hazards	• Improved understanding of systemic risks. • Improved estimation of damages and loss, cumulative impacts.
Integrating early warning systems with risk assessment (including extensive risks)	• Provision of real-time forecast of how weather-related hazards will impact on people's livelihoods • Account taken of cascading hazards in risk assessments, including vulnerability analysis
Management of extensive	• Provision of evidence-based estimates of extensive risk,

Research goals	Potential research impacts
risk	including suitable vulnerability analysis, for a range of hazards for urban and rural areas • Provision of direct and indirect, disaggregated losses that result from extensive risk especially for areas of informal housing in urban contexts • Consideration of the role for early warning in places exposed to frequent, creeping or extensive risk.
Using early warning systems to distinguish between "disastrous" events from "adverse" ones	• An improvement in the accuracy of distinguishing between these two types of event will allow pre-emptive actions to be taken early than previously
Effective use of recent developments in Information and Communication Technology (ICT)	• Provision of information that will allow an improved response to future disasters • Development of sustainable open platforms that are end-user driven • Development of real-time, continental scale hazard and risk maps for certain weather-related hazards • Development of how trust in ICT solutions can be improved with certain humanitarian actors and vulnerable communities • Increased capacity, especially in Africa and the Caribbean, to implement sustainable ICT-based solutions
Modelling of the health risks posed by weather-related hazards	• Acknowledgement of risks in health plans • Uptake of medium term and seasonal forecasts for planning humanitarian responses, e.g. ensuring timely mobilisation.
Contextualising and localising risk and early warning information	• Co-production of risk assessments and early warning systems with local stakeholders and responsible agencies. • Contextualisation of warning messages so that they are relevant to the livelihoods of the beneficiaries • An evidence-base for the use of scientific and indigenous forecasting methods
Effective communication of warnings	• Improvements in response as a result of more effective communication • Use of probabilistic warnings to improve lead times for certain groups of stakeholders
Sustainability of effective early warning systems between major events	• Protocols that allow successful volunteer based early warning dissemination to be "transplanted" to other countries and regions • Improvements in the sustainability of early warning systems • Use of early warning systems to disseminate other information that is useful for beneficiaries (e.g. health information)
Scaling-up successful community-level early warning systems and risk assessments	• Frameworks that allow successful community-based initiatives to be scaled up to a sub-national and national scale

SECTION 1

Introduction

1.1 Background

In 2012 the Intergovernmental Panel on Climate Change (IPCC) Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) described the interaction of climatic, environmental, and human factors that can lead to impacts and disasters and some of the options for managing these risks. It found that fatality rates and economic losses expressed as a proportion of gross domestic product (GDP) were higher in developing countries with small island developing states facing the greatest magnitude of damages and loss (IPCC, 2012).

More recently the Global Assessment Report on Disaster Risk Reduction reported that historical losses have been underestimated, with direct disaster losses at least 50% higher than internationally reported figures. Amongst the report's conclusions are recommendations for strengthening the links between climate risk assessment and disaster risk reduction as well as embedding disaster risk reduction more strongly into business processes to promote sustainable development and economic growth (UNISDR, 2013).

The UK Government's Department for International Development (DFID) responsibilities include providing humanitarian aid targeted at the most vulnerable people and promoting effective disaster risk reduction and climate change adaptation (DFID, 2011). In 2011 the Humanitarian Emergency Response Review identified the need to make better use of science in predicting and preparing for natural disasters and in informing investments in resilience. It concluded that a lack of reliable risk information and early warnings can be a considerable barrier to effective response to humanitarian emergencies.

The proposed Science for Humanitarian Emergencies and Resilience (SHEAR) programme aims to help close the gap through investing in research to bring forward the next generation of more systematic, transparent and comprehensive risk information and early warning systems for humanitarian and development purposes. This scoping study aims to provide recommendations on future ***research priorities*** for risk assessments and early warning systems for weather-related hazards (e.g. cyclones, floods, droughts, landslides) for humanitarian and development purposes.

1.2 Aims and scope

The SHEAR scoping study's overall aim is to make evidence-based recommendations on priorities for future research on risk assessment and early warning systems and their integration into decision making, through literature surveys, stakeholder workshops and gap analyses. In addition the study considers the status of current risk information in low income countries across Africa, South Asia and the Caribbean, on-going activities in these areas and where DFID can add value through investing in research.

It is important to note that this scoping study covers research and not operational gaps, although there is some times an overlap between the two.

In the context of this document, risk has been defined as the combination of the probability of a natural hazard occurring and its potential adverse consequences for people. Hence, to assess the humanitarian risk posed by weather-related hazards it is necessary to have information about the probability and characteristics of the hazard, together with the vulnerability and exposure of the people and systems affected (including their capacity to respond, recover from and share costs of risk reduction and any residual damage). The terms “hazard” and “risk” are often, incorrectly, used synonymously.

1.3 Report structure

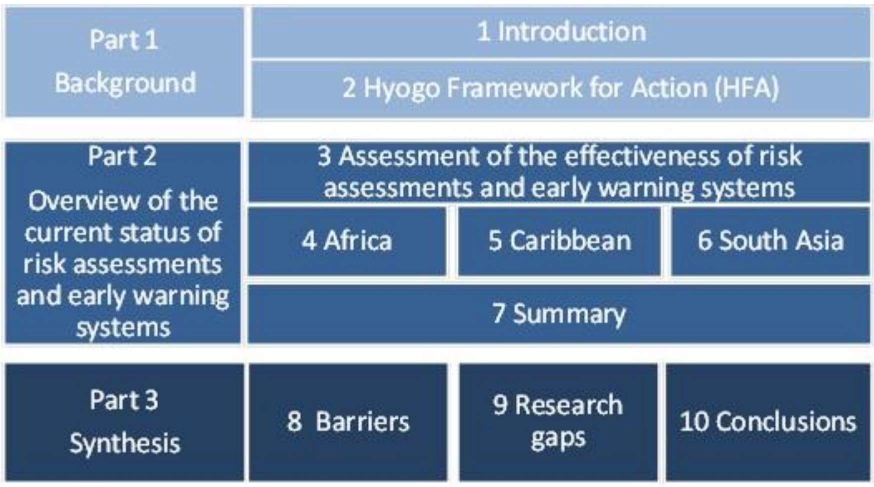
The report is structured in three main parts.

- Part 1 provides an introduction to the project and current progress on the United Nation International Strategy for Disaster Reduction’s (UNISDR) Hyogo Framework for Action.

- Part 2 presents our own assessment of the effectiveness of risk assessments and early warning systems based on user surveys and interviews with individual sections on Africa, the Caribbean and South Asia.

- Part 3 provides a synthesis of evidence from the surveys, literature reviews and project workshops; it identifies the main barriers to effective risk assessments and early warning systems, research gaps and main conclusions of the study.

The main report structure and section numbers are summarized below. A full list of references and stakeholders involved in the study are provided in Sections 11 and 12.



The report is accompanied by six Annexes that have provided evidence to support the findings detailed in this report. These annexes have been produced as stand-alone reports and are as follows:

- **Annex 1 - Results of a stakeholder survey**[2] detailing the findings of an internet-based survey aimed at practitioners, and to a lesser degree researchers, based in or working in the three regions, asking them about the effectiveness of early warning systems and risk assessments

2 Download Annex 1 from: http://dx.doi.org/10.12774/eod_cr.june2014.brownetal

- **Annex 2 - Literature review**[3] of the current status of early warning systems and risk assessments in the three regions
- **Annex 3 - Community-based case studies**[4] detailing seven case studies in Africa, three in South Asia and one in the Caribbean and the research requirements from a community-based perspective
- **Annex 4 - Current initiatives and research priorities in the Caribbean**[5]. Research undertaken in the Caribbean is often poorly documented and disseminated. As a consequence the Caribbean Institute for Meteorology and Hydrology carried out a short study to identify current relevant initiatives and to detail research gaps and needs
- **Annex 5 – Workshop report, London 9 December 2013**[6] This report summarises the discussion from a workshop attended by approximately 40 UK-based researchers and some users of information such as Non-Governmental Organisations working in the three regions
- **Annex 6 - Notes from a Caribbean workshop and stakeholder engagement**[7] This summarises engagement with Caribbean stakeholders that took place via the Caribbean Disaster Emergency Management Agency (CDEMA) eight annual Caribbean Conference on Comprehensive Disaster Management 2 to 6 December 2013 and the third International Conference on Climate Services (ICCS) 3 to 6 December 2013 both of which were held in Montego Bay in Jamaica
- **Annex 7 – Notes from a workshop and relevant meetings attended in Nairobi, Kenya** This included a half day workshop was held on 29 January 2014 at the United Nations (UN) and attendance at a conference entitled “Strengthening technological capacities and information access for improving disaster risk reduction in the Horn of Africa” on 22 and 23 January 2014 and workshop held by the Red Cross entitled “Early Warning Early Action: Research at regional level and country case studies in Uganda, Kenya and Ethiopia - An evidence base to inform strategic investment in early action systems in the region” on 30 January 2014

This report utilises the evidence collated in the above Annexes, as well as consultations with relevant researchers that took place over the course of the scoping study via interviews, a session held with stakeholders from the Caribbean at the third International Conference on Climate Services held in Jamaica in December 2013, a workshop that was held in London with relevant UK-based researchers in December 2013 and a workshop held in Nairobi, Kenya in January 2014.

1.4 Background to the impacts of weather-related hazards in the three regions

In terms of their consequences, the four main weather-related natural hazards that affect Africa, the Caribbean and South Asia are:

- **Floods** – Floods generally come about as the result of excess rainfall resulting in high river discharges and/or surface water inundation, as well as coastal surges causing extreme sea levels and inundation of coasts and estuaries.
- **Drought** – These are caused by a deficiency of rainfall, soil moisture, river flows and groundwater recharge and generally develop slowly over periods of months to years.

3 Download Annex 2 from http://dx.doi.org/10.12774/eod_cr.june2014.lumbrosorance
4 Download Annex 3 from http://dx.doi.org/10.12774/eod_cr.june2014.brown
5 Annex 4 from http://dx.doi.org/10.12774/eod_cr.june2014.farrelletal
6 Download Annex 5 from http://dx.doi.org/10.12774/eod_cr.june2014.pearce
7 Download Annex 6 from http://dx.doi.org/10.12774/eod_cr.june2014.lumbroso

- **Cyclones** – Cyclones are areas of very low atmospheric pressure over tropical and sub-tropical waters that build up into a large, circulating mass of wind and thunderstorms up to hundreds of kilometres across that cause loss and damage owing to coastal flooding, heavy rainfall and high winds.
- **Mudslides and landslides** – These are generally local events that occur after periods of intense rainfall, prolonged saturation or undercutting on steep slopes with unstable soil or rock conditions

It is important to note that other weather-dependent phenomena such as fire, heat waves, air pollution episodes, dust-storms, vector and water-borne disease, avalanches and glacial lake outburst floods (GLOFs) can be locally significant (Wilby, 2009). Although most stakeholders were focused on the four main hazards, other research needs were highlighted at the London workshop such as the weather forecasting and early warning of malaria and also non-weather related hazards such as earthquakes and tsunamis. The issues of other weather-related hazards, multi-hazards and systemic risks are returned to in Sections 9 and 10.

Table 1 provides a ranking of the humanitarian and economic impacts of weather-related hazards in the three regions based on data that are available from the Centre for Research on the Epidemiology of Disasters (CRED) that maintains an Emergency Events Database (EM-DAT) and the response of stakeholders to an internet-based survey detailed in Annex 1. The EM-DAT database considers the total population affected as the sum of the number or mortalities, those injured, homeless, and affected by a specific event and estimated economic damage[8] using data from a number of institutions. It provides a simplified analysis and a starting point for considering the deeper vulnerability and capacity factors that influence human and economic impacts.

Humanitarian and economic impacts	Africa	The Caribbean	South Asia
Highest impact	Droughts	Cyclones	Floods
	Floods	Floods	Cyclones
	Cyclones	Droughts	Droughts
Lowest impact	Landslides	Landslides	Landslides

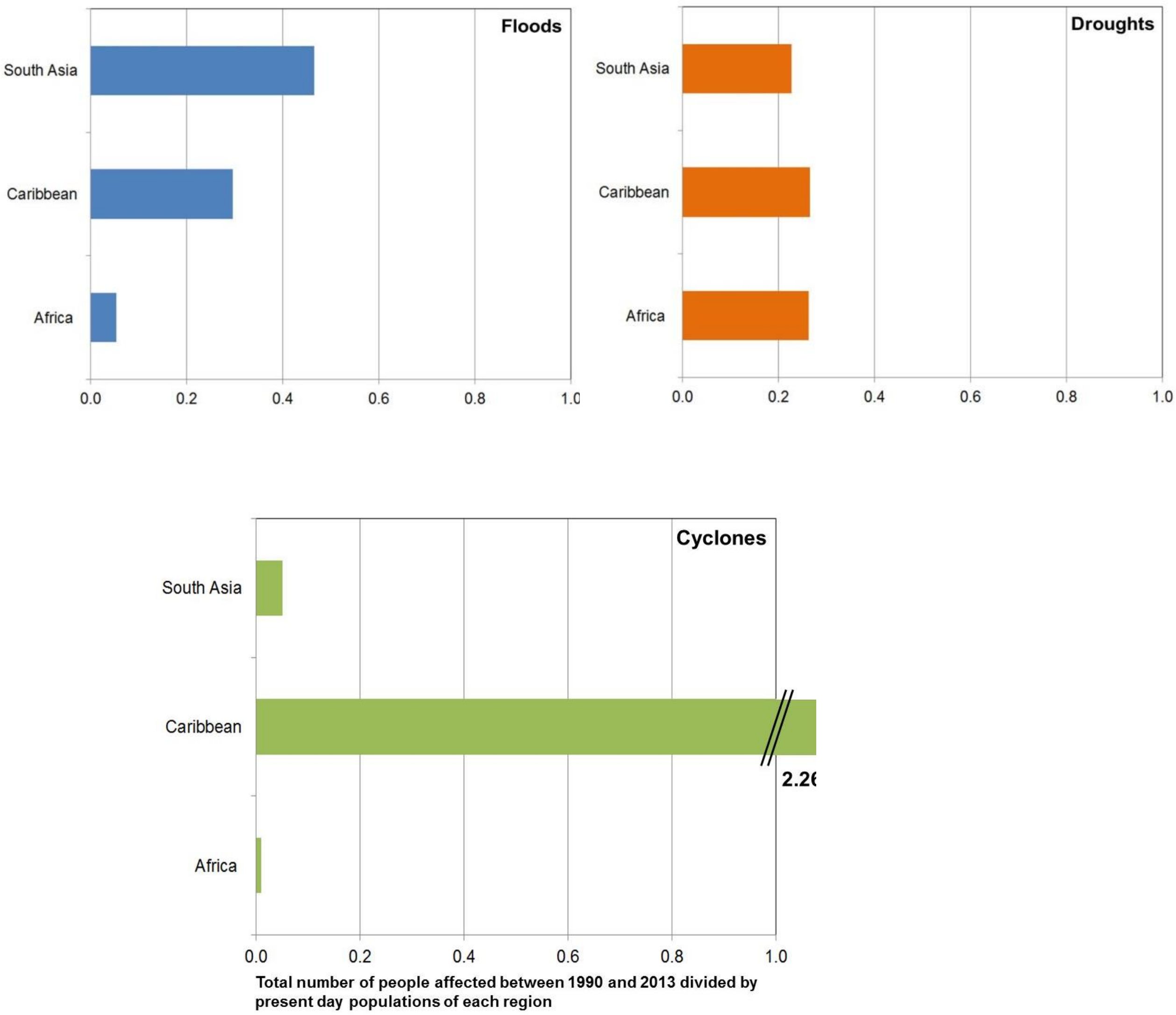
Table 1 The relative humanitarian and economic impacts of weather-related hazards in the three regions

Figure 1 shows the number of people affected[9] by weather-related hazards between 1990 and 2013 divided by the present day population for each of the three regions. This allows the relative risk to people to be compared.

It should be noted that landslides are not shown in Figure 1 owing to their relatively low direct humanitarian and economic impact in the three regions. However, landslides can have indirect impacts that are not recorded in the EM-DAT databases, for example disruption to critical transport or energy infrastructure could have important local or even national economic consequences. Further details of the impacts of weather-related hazards in the three regions between 1990 and the present day are provided in Annex 2.

[8] For definitions used in the EM-DAT database see www.emdat.be/criteria-and-definition
[9] This is the number of people requiring immediate assistance during a period of emergency, i.e. requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance.

Figure 1 Total number of people affected by weather-related hazards between 1990 and 2013 divided by present day populations[10]



Source: CRED 2013.

Note that these data are for a 24 year period and therefore the high ratio for Caribbean cyclones highlights a series of cyclone events that may have affected the same population several times

10 Assuming present day populations of approximately 1.0 billion, 7.0 million and 1.6 billion for Africa, the Caribbean and South Asia respectively, based on World Bank figures

SECTION 2

The Hyogo Framework for Action: Current status of risk assessments and early warning systems

2.1 Introduction

The Hyogo Framework for Action (HFA) is the first plan to explain, describe and detail the work that is required from all different sectors and actors to reduce disaster losses[11]. It was developed and agreed on with the many partners needed to reduce disaster risk - governments, international agencies, disaster experts and many others - bringing them into a common system of coordination. The HFA outlines five priorities for action, and offers guiding principles and practical means for achieving disaster resilience. Its goal is to substantially reduce disaster losses by 2015 by building the resilience of nations and communities to disasters. This means reducing loss of lives and social, economic, and environmental assets when hazards strike.

This section provides maps of the relevant Hyogo Framework for Action (HFA) scores based on official government reporting to the UN and some additional commentary based on the first ever independent assessment of progress at the local level by the Global Network of Civil Society Organisations for Disaster Reduction (GNCSODR).

2.2 Mapping of the Hyogo Framework for Action (HFA) scores

The Hyogo Framework for Action (HFA) is a 10 year plan initiated by the United Nations (UN) that commenced in 2005, to make the world safer from natural hazards (UNISDR, 2007). The HFA has been adopted by 168 states. The three main strategic goals are:

- The integration of disaster risk reduction into sustainable development policies and planning
- The development and strengthening of institutions, mechanisms and capacities to build resilience to hazards
- The systematic incorporation of risk reduction approaches into the implementation of emergency preparedness, response and recovery programmes

It should be noted that there is no binding text for disaster risk reduction as part of the HFA, i.e. a strategy which defines what should be achieved within a defined period of time.

Priority 2 of the five HFA priorities is to "*identify, assess and monitor disaster risks and enhance early warning*" (UNISDR, 2007). As part of Priority 2 there are two main indicators that are relevant to the SHEAR scoping study. These are:

- HFA Priority 2, core indicator 2.1: National and local risk assessments based on hazard data and vulnerability information are available and include risk assessments for key sectors

[11] For further details refer to the HFA web pages http://www.unisdr.org/we/coordinate/hfa

- HFA Priority 2, core indicator 2.3: Early warning systems are in place for all major hazards, with outreach to communities

Under the HFA there is a five-level assessment tool for use by governments in grading the achievements in the indicators, these are detailed in Table 2.

Hyogo Framework for Action (HFA) level	Achievements
Level 1	Minor progress with few signs of forward action in plans or policy
Level 2	Some progress, but without systematic policy and/or institutional commitment
Level 3	Institutional commitment attained, but achievements are neither comprehensive nor substantial
Level 4	Substantial achievement attained but with recognized limitations in key aspects, such as financial resources and/or operational capacities
Level 5	Comprehensive achievement with sustained commitment and capacities at all levels

Table 2 Hyogo Framework for Action (HFA) five level assessment tool

The HFA core indicators 2.1 and 2.3 have been mapped for the three regions. The scores have been taken from the latest available HFA progress reports available for each country. Most of these reports cover the period 2011 to 2013. There are many countries that have not produced HFA progress reports. It is also important to note that the HFA progress scores are qualitative, in that they are judged by government officials and the evidence collected may not always reflect the views of stakeholders within the countries as to the level of progress that has actually been made, judging by the evidence collected as part of this study. It may also not be comparable across countries given the subjective application of the assessment tool.

2.2.3 HFA core indicator 2.1: National and local risk assessments

HFA core indicator 2.1 relates to national and local risk assessments. There does not appear to be a definition under the HFA as to what constitutes a national or local “risk assessment”. The means of verification are based on the availability of:

- Multi-hazard risk assessments
- Percentage of schools and hospitals assessed
- Percentage of schools not safe from disasters
- Gender disaggregated vulnerability and capacity assessments
- Agreed national standards for multi hazard risk assessments (UNISDR, 2007)

Figures 2, 5, and 7 show maps of the HFA core indicator 2.1 for Africa, the Caribbean and South Asia respectively. It is important to note that these HFA indicators are based on qualitative criteria and are subjective. It is thus difficult to make a comparison between the three regions.

2.2.4 HFA core indicator 2.3: Early warning systems

HFA core indicator 2.3 relates to early warning systems for all major hazards. The means of verification are based on the evidence that:

- Early warnings are acted on effectively
- Local level preparedness is in place
- Communication systems and protocols are in place
- There is active involvement of media in early warning dissemination (UNISDR, 2007)

Figures 3, 6, and 8 show maps of the HFA core indicator 2.3 for Africa, the Caribbean and South Asia respectively.

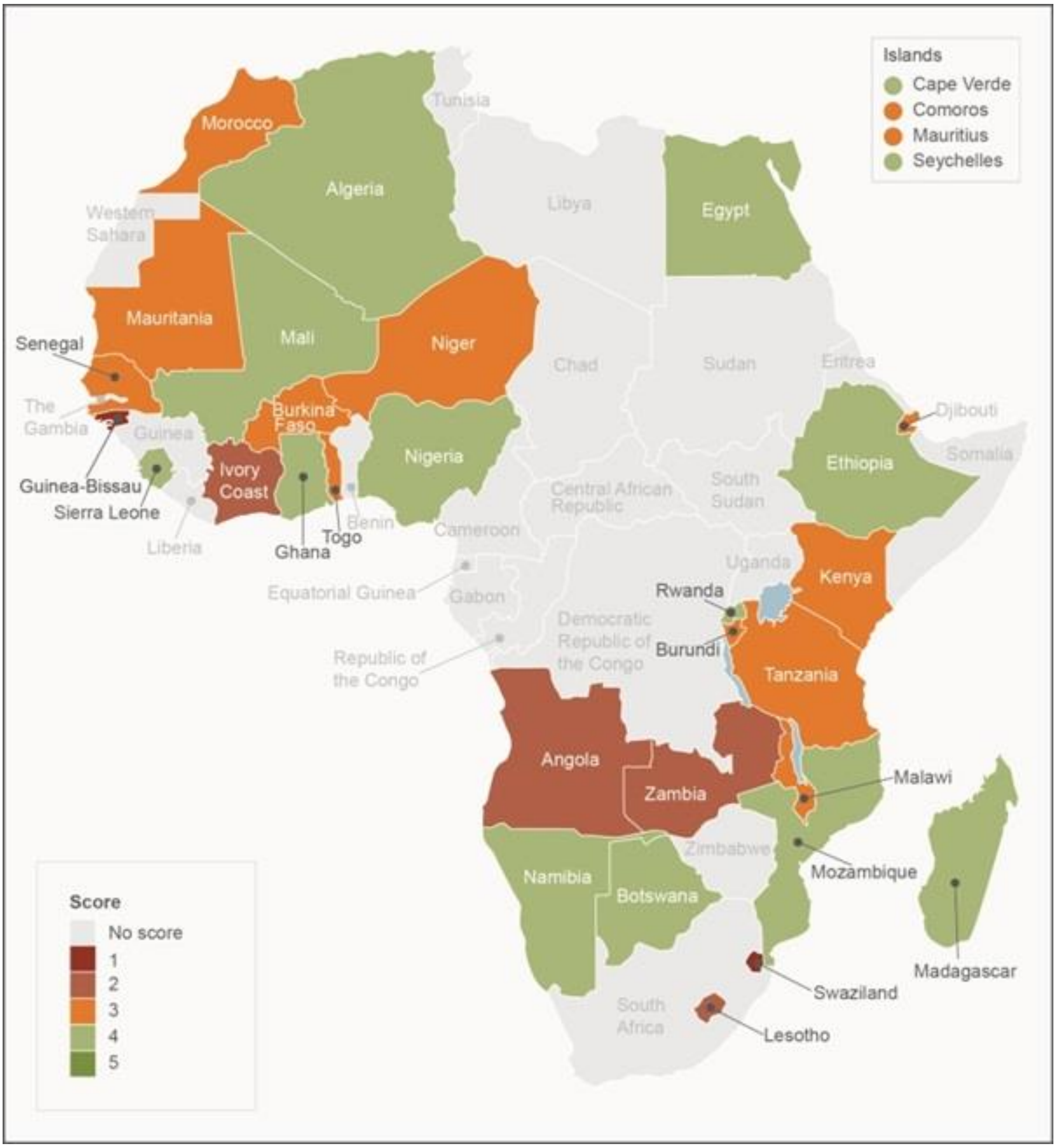
2.2.5 Overview of HFA scores for the three regions

The evaluation of HFA core indicators 2.1 and 2.3 has shown that progress has been disparate across the three regions and this coupled with the ambiguous nature of how the scores have been produced by each of the states means that it is difficult to draw any firm conclusions. Some general points are summarised below:

- In Africa progress on risk assessments is variable with acknowledgement of the very slow progress in several countries such as Angola, Zambia and the Ivory Coast. Progress with respect to early warning systems appears to be marginally better with an 'institutional commitment' (level 3) in most countries but also a recognition that more needs to be done.
- In the Caribbean progress is also mixed and it is notable that vulnerable countries, such as Haiti, acknowledge only 'minor progress' in risk assessments and early warning systems, while Cuba's government report 'substantial achievements'.
- In South Asia there appears to have been more progress and institutional commitment (level 3) in all countries that returned HFA progress reports; Pakistan and Nepal appear to be lagging behind India on risk assessments and early warning systems.

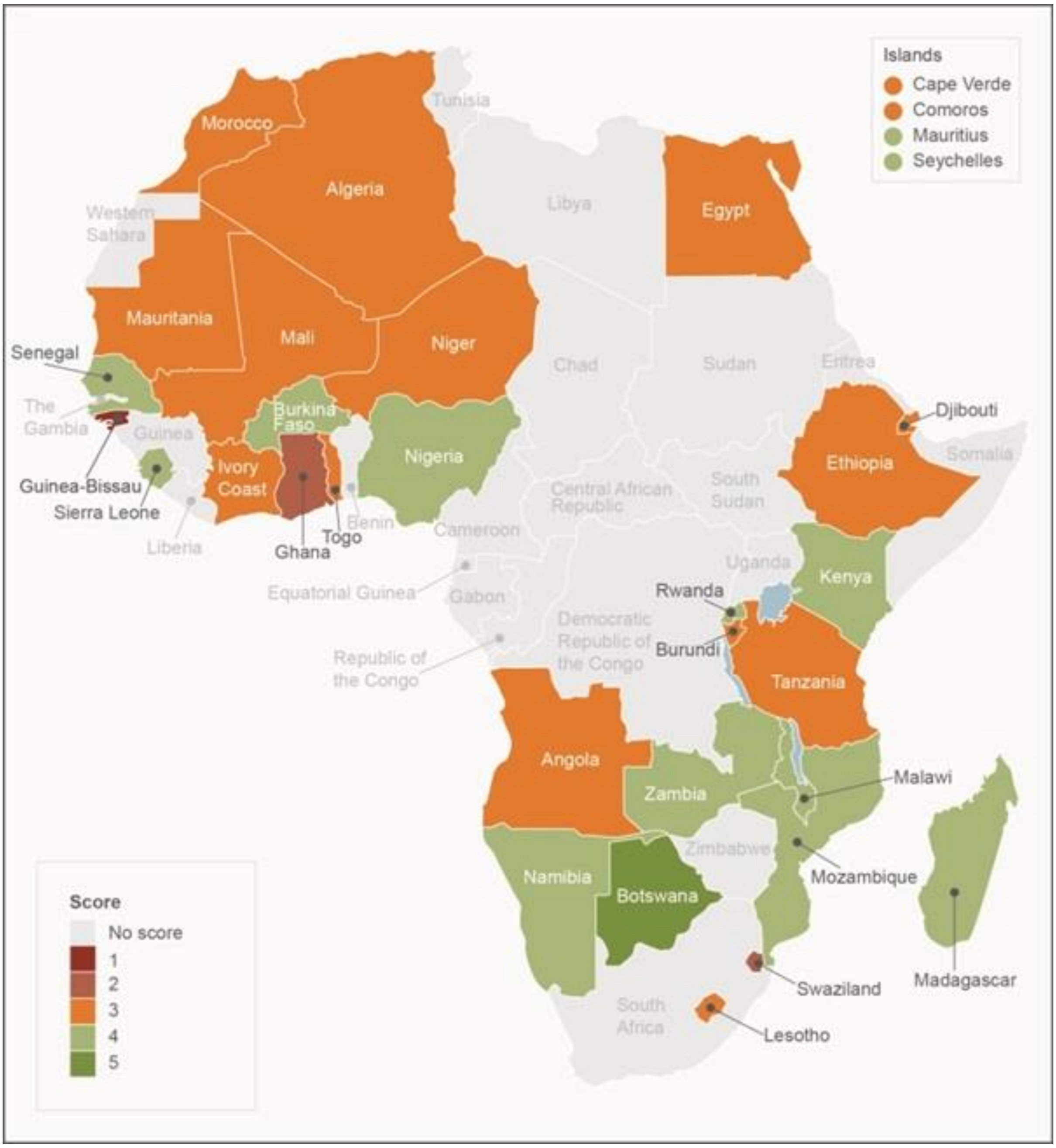
Where it is indicated that there is "no score" for a particular country, this does not mean that risk assessments or early warning systems do not exist, it simply means that the country has not published an HFA score for the relevant indicator. Comparing the HFA indicators with the Gross Domestic Product (GDP) for 2011 in US$ for each country in each region shows no correlation between the size of the economy and the progress made in achieving the HFA core indicators relevant to SHEAR.

Figure 2 HFA core indicator 2.1: National and local risk assessments for Africa



Source: HFA national progress reports

Figure 3 HFA core indicator 2.3: Early warning systems for Africa



Source: HFA national progress reports

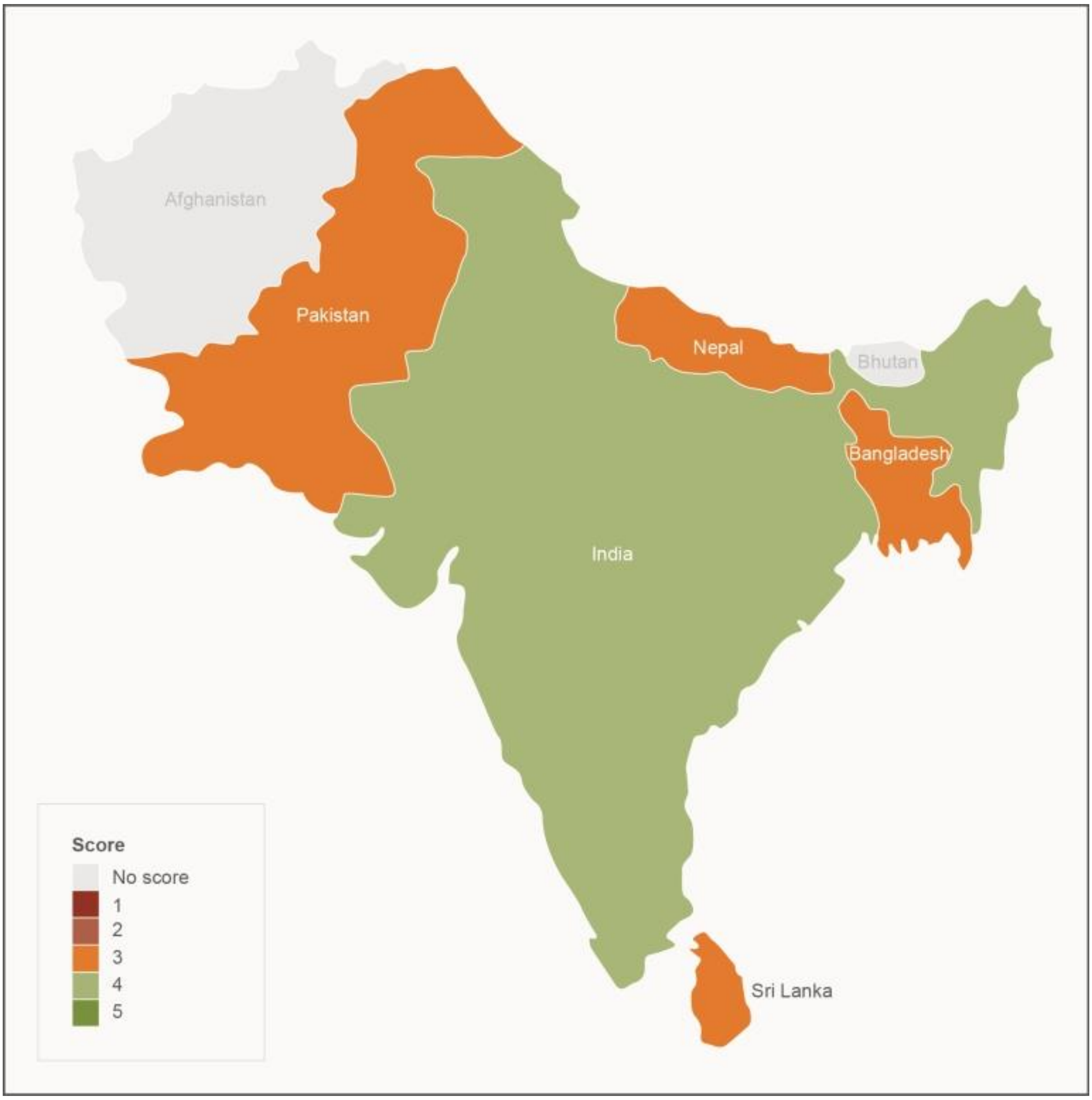
Figure 4 HFA core indicator 2.1: National and local risk assessments for the Caribbean

Source: HFA national progress reports

Figure 5 HFA core indicator 2.3: Early warning systems for the Caribbean

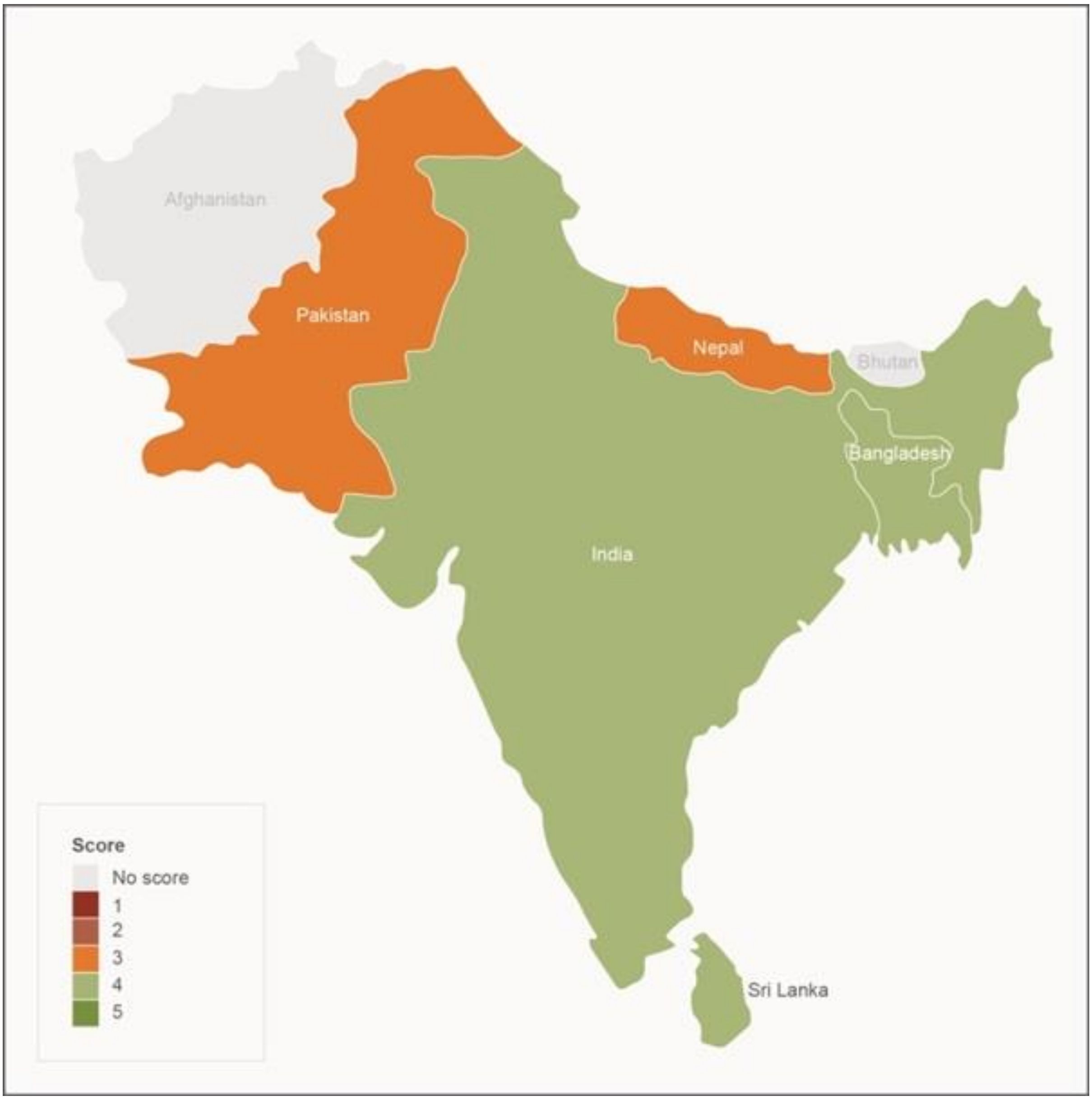
Source: HFA national progress reports

Figure 6 HFA core indicator 2.1: National and local risk assessments for South Asia



Source: HFA national progress reports

Figure 7 HFA core indicator 2.3: Early warning systems for South Asia



Source: HFA national progress reports

2.2.6 The local view of progress towards HFA indicators

In 2009 Global Network of Civil Society Organisations for Disaster Reduction (GNCSODR) carried out the first ever independent assessment of progress undertaken towards implementation of the HFA at the local level. The review covered 48 countries in Africa, Asia and the Americas. In the context of this scoping study the assessment covered nine countries in Africa, one in the Caribbean and the whole of South Asia. The work included 5,290 survey questionnaires (primarily through face-to-face interviews) with three stakeholder groups: local governments, civil society organisations and community representatives (GNCSODR, 2009).

The review found a significant gap between national and local level action (GNCSODR, 2009). The reports of progress towards the HFA indicators were found to "fade" as activities get closer to vulnerable people where the "*impact is at best limited and patchy and at worst not happening at all*" (GNCSODR, 2009). The data collected the by the GNCSODR showed significant differences between the level of perceived progress by the three groups: local government, civil society organisations and community groups. Communities indicated progress as being "very limited progress' which was consistently lower than both local government and civil society scores. Women assessed progress lowest overall.

According to local views, the HFA priorities showing least progress were HFA Priorities for Action (PFA) 1 relating to governance and PFA 2 relating to assessment and monitoring of risk and early warning systems. The work carried out suggested that the greatest progress had been made in countries that have adopted community and local level approaches to disaster risk reduction, such as Bangladesh, although it is stated that "*the relationship between progress and participation requires further research*" (GNCSODR, 2009).

SECTION 3

Methods to assess the effectiveness of risk assessments and early warning systems

3.1. Assessment framework

This section describes an analytical framework based on a simple scoring system that was combined with the results of a stakeholder survey to assess the "effectiveness" of risk assessments and early warning systems in the three regions. Evidence was gathered based on stakeholder consultations via a series of interviews and internet survey involving more than 300 stakeholders (see Annex 1), a literature review (see Annex 2) and a series of case studies (see Annex 3).

For risk assessments the aspects that were considered in assessing effectiveness are tabulated in Table 3.

Aspect	Factors evaluated
Robustness	Are data availability/quality a constraint in providing information?[12]
Reliability	Is there evidence that people are using the information and if so what are they using it for?
Access	Is the information clearly communicated? How is it communicated?

Table 3 Aspects considered in assessing the effectiveness of risk assessments

For early warning systems the aspects that were considered in assessing their effectiveness are tabulated in Table 4.

Aspect	Factors evaluated
Robustness	Can sufficiently accurate and timely warnings be generated? Is data availability/sharing a constraint in providing information? Are data quality a constraint in providing information?
Reliability	Are the warnings dependent on the forecasts of Meteorological Services from outside the country in question? Are there enough adequately trained staff/volunteers?
Access	Are a variety of warning methods used? Can all stakeholder groups access the information?
Response	Are there associated training programmes or mock drills in place? Is the institutional framework in place to respond to system information?

Table 4 Aspects considered in assessing the effectiveness of early warning systems

12 It should be noted that often measures of robustness of risk assessments would encompass other factors such as strength of evidence, consensus, validation, peer review or the appropriateness methods used. However, the information available was not sufficiently detailed to allow these questions to be addressed.

EVIDENCE ON DEMAND
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As part of an internet survey (see Annex 1) stakeholders in the regions were asked their views on the effectiveness of early warning systems and risk assessments in reducing loss of life for various hazards, as well as their accessibility to a range of different users (e.g. the public, local government, national government, the media). When assessing the "effectiveness" of risk assessments and early warning systems for weather-related hazards information from the literature review, one-to-one interviews and the internet survey were taken into account.

The effectiveness of early warning systems or risk assessment was mapped using a scoring system detailed in Table 5.

Score	Factors evaluated
1	An early warning systems or risk assessments exists but it is not particularly effective
2	An early warning systems or risk assessments exists and is deemed to be "moderately effective" in reducing humanitarian impacts
3	The early warning systems or risk assessments that are in place are "effective" in that they lead to the desired response that results in a reduction in the impacts of the weather-related hazards
No information	There was insufficient evidence available to judge the effectiveness of the early warning system or risk assessment

Table 5 Scoring system used to denote the effectiveness of risk assessments and early warning systems for weather-related hazards in the three regions

There has been a degree of subjectivity in assessing the "effectiveness" of early warning systems and risk assessments; however, this analysis still allows the gaps to be readily identified. It is difficult to state categorically that for certain countries that an early warning system or risk assessment does not exist. Results from the internet survey (see Annex 1) indicated that in some cases stakeholders from the same country provided different opinions as to whether these were in place and also there is often disagreement on their effectiveness. Hence, rather than state that there is no system in place a "no information" category has been employed.

It is interesting to note that, in general, details in the literature are sparse on the regular monitoring or post-event evaluation of the impact of risk assessments and early warning systems. For risk assessments this is often a question of data quality especially in rapidly changing social contexts e.g. urban areas. For early warning this is a question of using loss data to judge effectiveness and how to improve this over time and with internal drivers and not waiting for the next external aid initiative before initiating any changes.

The outputs of this assessment are presented as a series of maps and commentary based on interviews in Sections 4, 5 and 6 for Africa, the Caribbean and South Asia respectively.

3.2 Stakeholder engagement

As part of this scoping study stakeholders were engaged with via a variety of methods:

- An internet-based survey which attracted 247 responses from stakeholders involved with risk assessments and early warning systems in the three regions
- A number of workshops and attendance at a number of meetings including the following:
    - The Caribbean Disaster Emergency Management Agency (CDEMA) on 2 to 6 December 2013, Jamaica

- A workshop session at the Third International Climate Change Services (ICCS) conference on 4 to 6 December to engage with stakeholders based in the Caribbean
- A one day workshop on 9 December 2013 held in London to engage primarily with UK-based researchers and users of information who are
- carrying out work on risk assessments and early warning systems in the three regions
- An invitation only regional-discussion forum on Strengthening technological capacities and information access for improving disaster risk reduction in the Horn of Africa organised by the Intergovernmental Authority on Development (IGAD) on 22 to 23 January 2014 in Nairobi. Kenya
- A half day workshop held at the United Nations Environment Programme (UNEP) office on 29 January 2014 in Nairobi, Kenya with researchers and users of the information working on risk assessments and early warning systems in Africa
- A one day workshop organised by the Red Cross on 30 January 2014 in Nairobi, Kenya entitled “Early warning, early action” that focused on early warnings, primarily for drought, in Ethiopia, Kenya and Uganda

- Approximately 30 telephone or face-to-face interviews and discussions primarily with researchers working in the three regions that were carried out between November 2013 and January 2014

Details of the stakeholder engagement are provided in Annexes 1, 5 and 6. A list of the survey and workshop participants is included in Section 12.

SECTION 4

Africa – Overview of the current status of risk assessments and early warning systems

4.1 Introduction

In 2007 a report by International Council for Science (ICS) on natural and human-induced hazards in Africa stated that "*Africa is, in many ways, the continent most in need of scientific knowledge to provide solutions and assist its socio-economic development. However, investment in science, technology, and innovation is frequently a low priority for decision- and policy-makers, and scientific institutions have relatively weak infrastructures*". (ICS, 2007).

This section focuses on floods, droughts, cyclones and landslides. However, it is important to recognise that there are weather-related hazards such as dust storms, (primarily in the Sahel and Sahara), that could be linked to outbreaks of meningitis outbreaks, wildfires and heat waves, as well as storms on the African Great Lakes (e.g. Lake Malawi, Lake Victoria) that can pose a danger to fishermen. In addition there are clear climate and environmental drivers for malaria with rainfall defining the transmission season by providing breeding sites for mosquitoes and temperature impacts on mosquito life cycles (Pappenberger, et al. 2013).

4.2 Floods

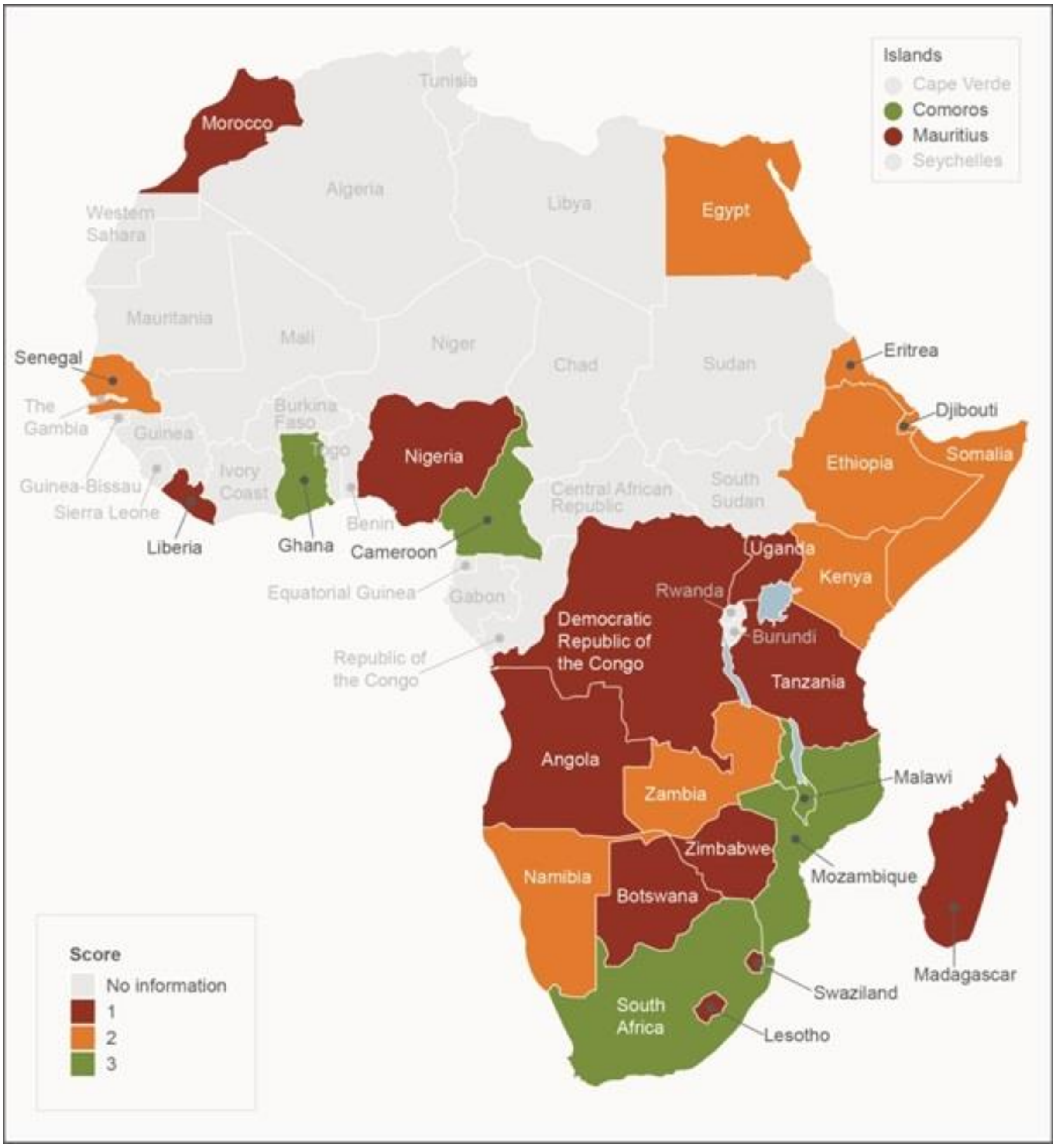
4.2.1 Risk assessments for floods

Figure 8 shows the assessment of effectiveness of flood risk assessments for Africa using the analytical framework. Of the 54 sovereign states in Africa only seven where found to have "effective" risk assessments for floods. Of these seven countries, South Africa has produced flood hazard maps for the areas of highest risk for at least the past two decades and in Mozambique, since the floods of 2000 that killed approximately 800 people and led to one million people being displaced, there has been a concerted effort to carry out flood mapping for the major river basins and make an assessment of the risks.

In 2013 the Southern African Development Community (SADC) stated that in general risk identification is not effective owing to poor database management skills and lack of mapping skills (UNISDR, 2013b). Although there are some centres of mapping excellence in Africa (e.g. the Regional Center for Mapping and Resources for Development in Nairobi) and capacity building by organisations such as the United Nations Institute for Training and Research (UNITAR). In most African countries, there are often no comprehensive statistics quantifying the humanitarian impact of disasters on its people. For example, in 2010 when the UNISDR Regional Office for Africa evaluated existing disaster databases in Ethiopia, Kenya and Uganda, it was apparent that no systematic gathering of data had been taking place. Since then funding has been put in place to rectify this situation. However, the absence of data on exposure, vulnerability and risk to both people and their livelihoods, as well as important assets (e.g. education and health facilities) is common in many African countries.

In general the coverage of good quality flood hazard maps for a range of probabilities covering the majority of the continent has considerable room for improvement. There are some exceptions for example, in. South Africa flood hazard maps have existed for most urban areas for the past 20 years. There have also been some community-based flood hazard mapping initiatives in Africa (for examples see Red Cross, 2004; Kienberger, 2007; Benjamin, 2011; EPA, 2012; Fabiyi et al., 2012). However, these rarely appear to be integrated with flood hazard mapping initiatives taking place at a national scale. To conclude, flood hazard mapping for Africa would appear to be piece meal and flood risk mapping, where the exposure and vulnerability of people to flooding is taken into account, has not been widely undertaken, and where it has it has been based on limited data.

Figure 8 The effectiveness of risk assessments for floods in Africa

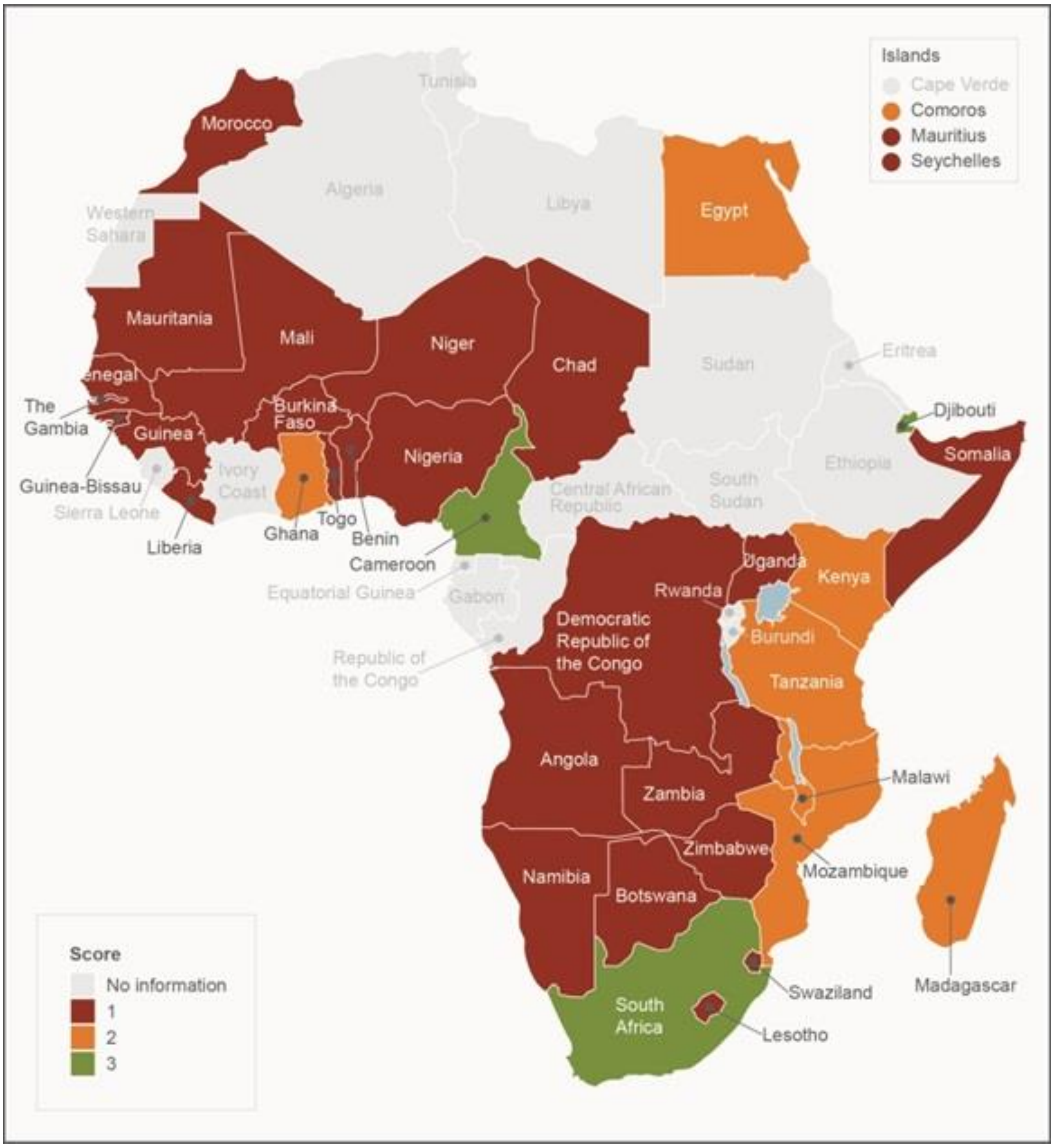


4.2.2 Early warning systems for floods

Figure 9 shows that in Africa there are only three states, (South Africa, Cameroon and Djibouti), where early warning systems for floods were adjudged to be “effective” by the analytical framework, and only a further seven (Egypt, Ghana, Kenya, Malawi, Madagascar, Mozambique and Tanzania) where early warning systems are “moderately effective”. It is important to note that in some cases these assessments are based on stakeholders’ perceptions of the early warning systems’ effectiveness. For example, in the case of Djibouti a flood forecasting system was only implemented in April 2013 and there have been no major floods since it was commissioned. However, the one Djiboutian stakeholder engaged with considered the system to have had a significant effect in reducing loss of life from flooding.

Most African states have some type of flood warning service (see Theimig et al., 2011); however, they would often not appear to be particularly effective in engendering the desired response by the users of the information.

Figure 9 The effectiveness of early warning systems for floods in Africa



In terms of early warning systems there have been many flood forecasting initiatives in Africa (see Annex 2 for more details). The main issues with early warning systems for floods in Africa are as follows:

- There have been many flood forecasting initiatives in Africa; however, warning information from these is often not easily accessible especially to the most vulnerable groups in society
- There is a requirement for increased technical capacity within the institutions responsible for flood forecasting and warning
- Warnings need to be improved. Two-way systems of communication between users and providers of information need to recognise the value of local information and create systems for ongoing reviews and revisions. This would help to ensure that the providers are informed by what worked, what needs revising, what the impacts were and what evolving needs the users have
- Real-time forecasts showing predicted flood extents are not readily available
- There is a need to link real-time forecasts dynamically to risks that flood pose to the most vulnerable in society in terms of both risk to life and their livelihoods
- There is a requirement for a complementary flood forecasting and early warning system for medium-ranged forecasts (i.e. lead times between five and 15 days)
- In some countries in Africa there is a lack of effective communication between national meteorological services, early warning systems and water management bodies

4.3 Droughts

There are three general types of drought: meteorological; agricultural and hydrological. A meteorological drought refers to a precipitation deficit over a period of time. An agricultural drought occurs when soil moisture is insufficient to support crops or livestock. A hydrological drought occurs when below-average water levels in reservoirs, rivers and groundwater, affect non-agricultural activities (e.g. water supply, energy production) (Wilhite and Buchanan-Smith, 2005; UNISDR, 2009)[13]. Droughts are typically characterised by a slow onset and a slow recovery. Recent improvements in modeling have meant that World Meterological Organisation (WMO) designated Global Producing Centres (GPCs) can forecast droughts up to six months in advance as was the case with La Niña and the drought in the Greater Horn of Africa in 2010/11 (Graham, 2014). .

In 2012 the United Nations Development Programme (UNDP) carried out a consultation exercise with more than 400 people working in drought-related fields in Africa and Asia. In both regions there were found to be very few examples of systems for drought risk assessment and the dissemination of early warning being well established and highly regarded (UNDP, 2012). The UNDP found that it was institutions who were responsible for early warning systems who expressed "*most of the few positive views*" (UNDP, 2012). The UNDP states that the "*divergence between the producers and users of the monitoring information raises a question about the feasibility and practicality of the existing drought assessment and early warning systems and processes*" (UNDP, 2012).

4.3.1 Risk assessments for droughts

[13] The drought classification can be taken further to 'water resources drought' where infrastructure constraints or 'gaps' can be the main cause of water scarcity and drought rather than water availability in rivers and groundwater resources.

Droughts have a significant humanitarian impact in Africa. Figure 10 shows the distribution of the effectiveness of drought risk assessments across Africa based on the analytical framework. In only three of 54 states was it assessed that drought risk assessments are effective.

Africa Risk Capacity (ARC) has developed an index-based insurance product at sovereign-state level to allow states to pay a premium to join a pooled-insurance scheme. A country receives a payout if predefined rules regarding the impact of a drought are met. This uses a piece of software called Africa Risk View (ARV). It should be noted that ARC is not yet fully operational and that the ARV does not account for other risk factors that exacerbate drought and household vulnerability during a rainfall season, such as increasing food price.

It is envisaged that, when operational, ARC payouts will support early needs assessment and to help countries improve the timeliness of their targeting of assistance to the most vulnerable populations. However, because ARC and the ARV software operate at a sovereign state level they do not allow the risk to be estimated at a disaggregated level.

4.3.2 Early warning systems for droughts

Figure 11 shows that there were only two countries in Africa, Mali and Lesotho[14], where either the stakeholders or the available evidence suggested that early warning systems for droughts are effective. The majority of countries in the Horn of Africa and the Sahel have “moderately effective” drought warning systems

Monitoring systems in African countries are inadequate considering the variability of precipitation and river flows, sizes of catchments/aquifers and variability of geophysical conditions (Graham, 2012) which makes the monitoring of drought in Africa challenging. Various authors (e.g. Nyabeze, 2011, Nyabeze et al., 2011; Graham, 2010; Graham et al., 2012; Iglesias and Garrote, 2012, UNESCO-IHE, 2011; UNDP, 2012) have discussed the status of drought early warning systems for Africa. Generally there is a need to improve the monitoring networks, temporal aspects of the forecasts (e.g. season onset, duration, and dry spell frequency) and to improve the communication to the most vulnerable. A drought hazard assessment at a continental scale in Africa to identify and predict drought through the analysis of long-term trend in vegetation patterns has been carried out; however, this does not look at the vulnerability information (Kaiser et al., 2003).

14 These were both based on limited stakeholder feedback from the internet-based survey carried out (see Annex 1)

Figure 10 The effectiveness of risk assessments for droughts in Africa

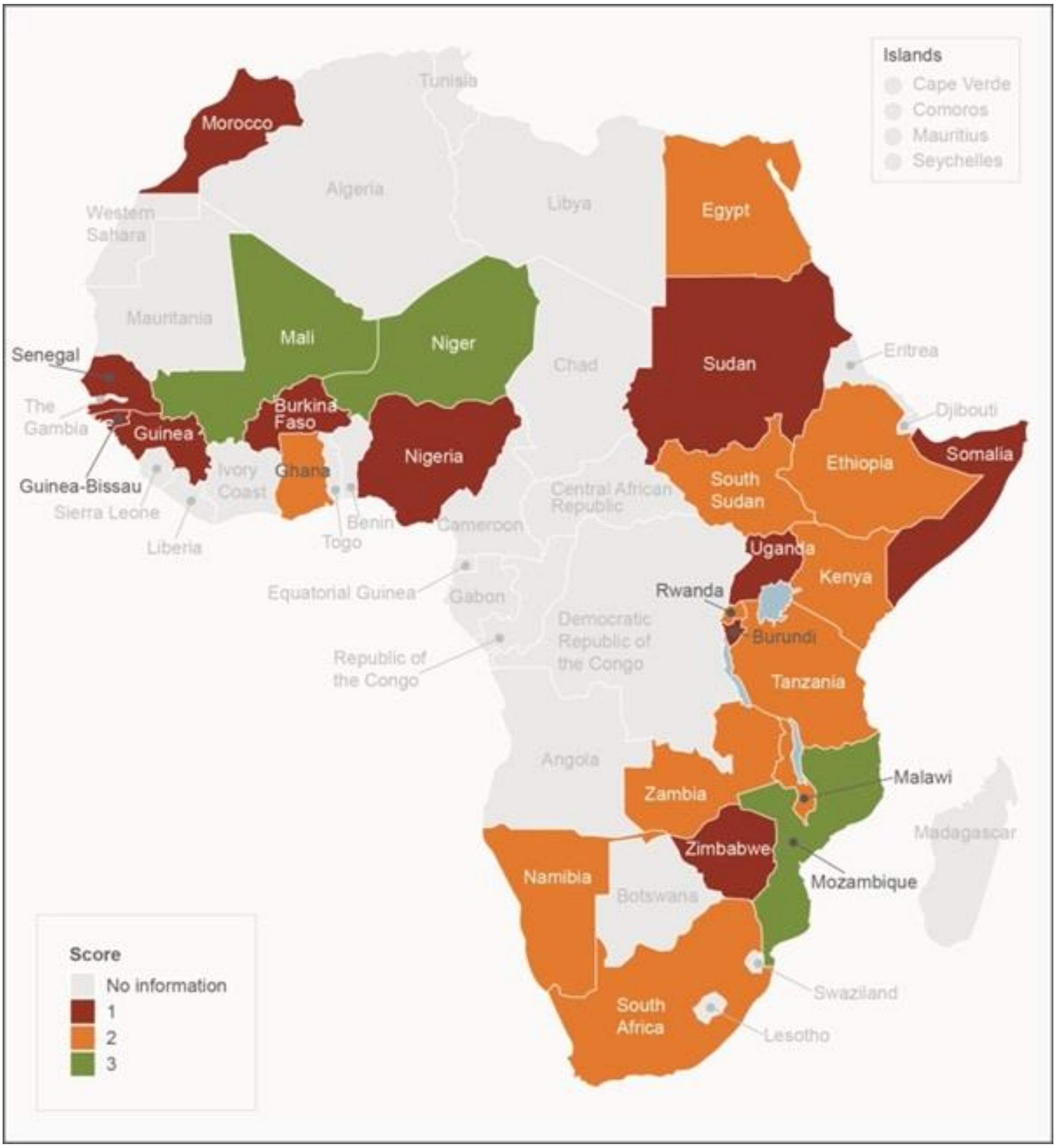
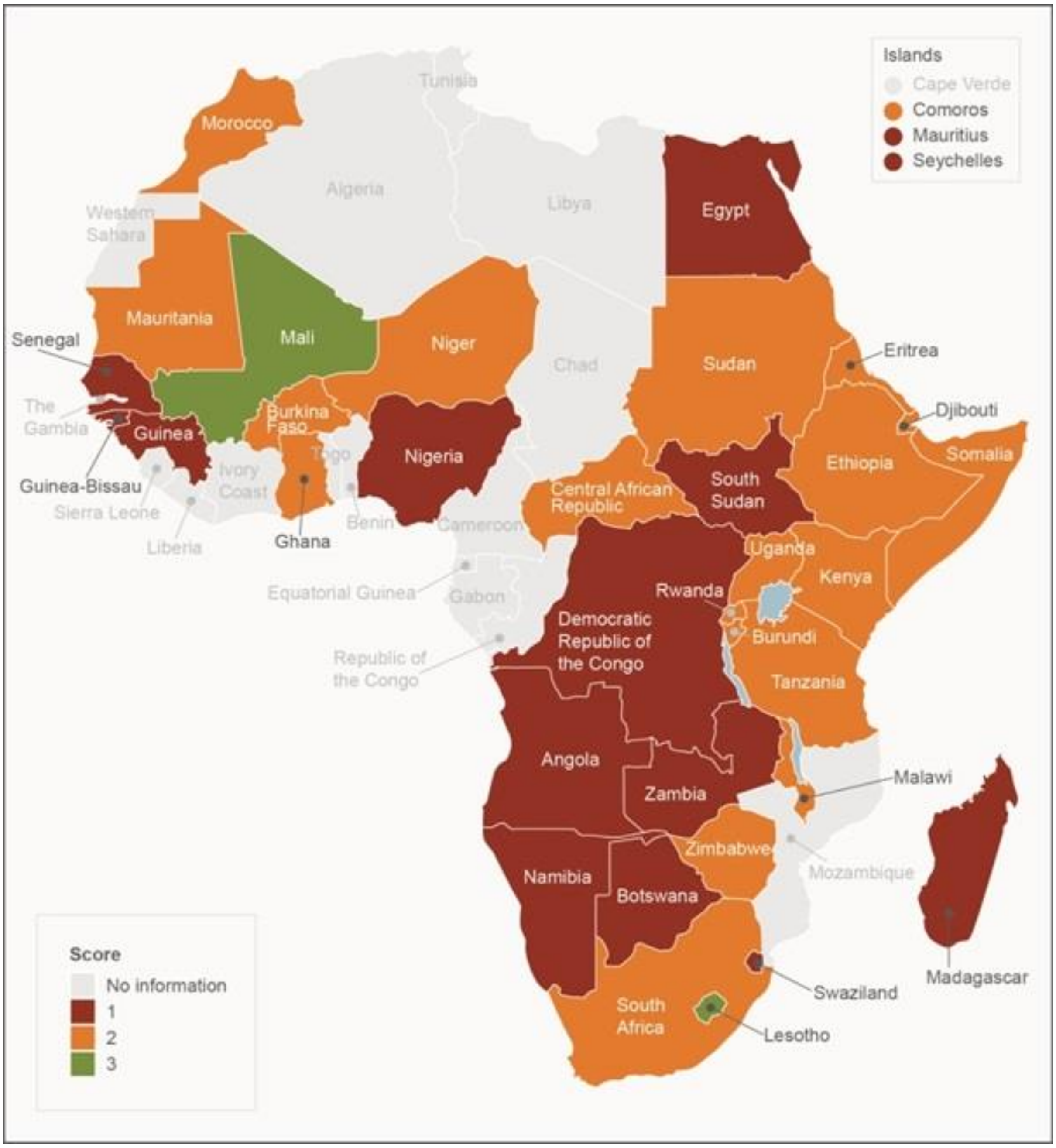


Figure 11 The effectiveness of early warning systems for droughts in Africa



4.4 Cyclones

In Africa tropical cyclones tend to predominantly affect the countries facing the Indian Ocean (i.e. Mozambique, Madagascar, Mauritius, the Comoros, the Seychelles and to a lesser degree South Africa, Tanzania, Kenya and Somalia). Of the 9.4 million people reported to have been affected by "storms" in Africa over the past 20 years, 8.9 million of these were in Madagascar or Mozambique (CRED, 2013).

4.4.1 Risk assessments for cyclones

Figure 12, based on the analytical framework, shows that it is only the Comoros islands, Madagascar and Mozambique that have some degree of effective risk assessment for cyclones. Mozambique is one of the countries in Africa most severely affected by cyclones and some work has been undertaken to produce a risk map for cyclones at a national scale; however, work on estimating the risk from cyclones in the rest of Africa would appear to be relatively limited.

4.4.2 Early warning systems for cyclones

As stated above, in Africa, cyclones have the most impact on countries facing the Indian Ocean. Using the analytical framework it was found that for most of the countries affected early warning systems for cyclones are moderately effective with Mauritius having the most effective system, as shown in Figure 13.

In terms of forecasting cyclones there have been initiatives to improve the capacity of national meteorological services in the region. One such initiative, run by the World Meteorological Organization (WMO) and supported by the Met Office, is the Severe Weather Forecasting Demonstration Project. The principal focus was on heavy rain and strong winds. The data provided as part of the project enabled the Mozambique meteorological service to provide warnings of strong winds and heavy rain, disseminated by a wide range of media, to the people five days ahead of the arrival of tropical cyclone Favio in February 2007. This is believed to have contributed to a significantly lower number of fatalities compared to the devastating floods in early 2000 caused by another tropical cyclone (Met Office, 2010).

In Mozambique a colour coded cyclone warning system has been developed (i.e. blue, yellow and red) to represent how long it is before high winds can be expected and what action to take. There is some evidence that these have been successful in communicating warnings to vulnerable populations in rural areas.

4.5 Landslides

There has been very little work undertaken into either landslide risk assessments or early warning systems in Africa. Neither does appear to be an operational early warning system for landslides anywhere in Africa.

Figure 12 The effectiveness of risk assessments for cyclones in Africa

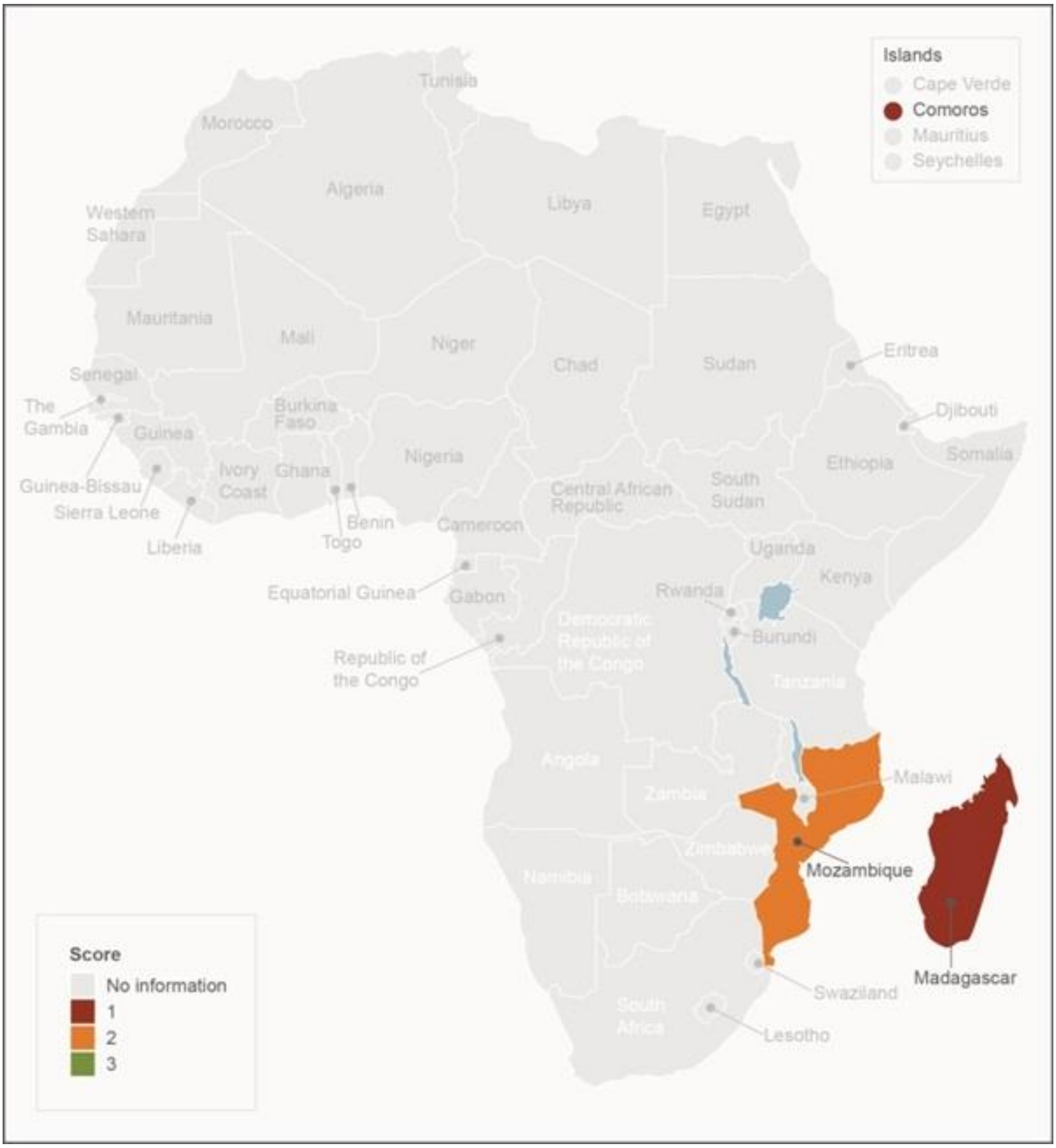
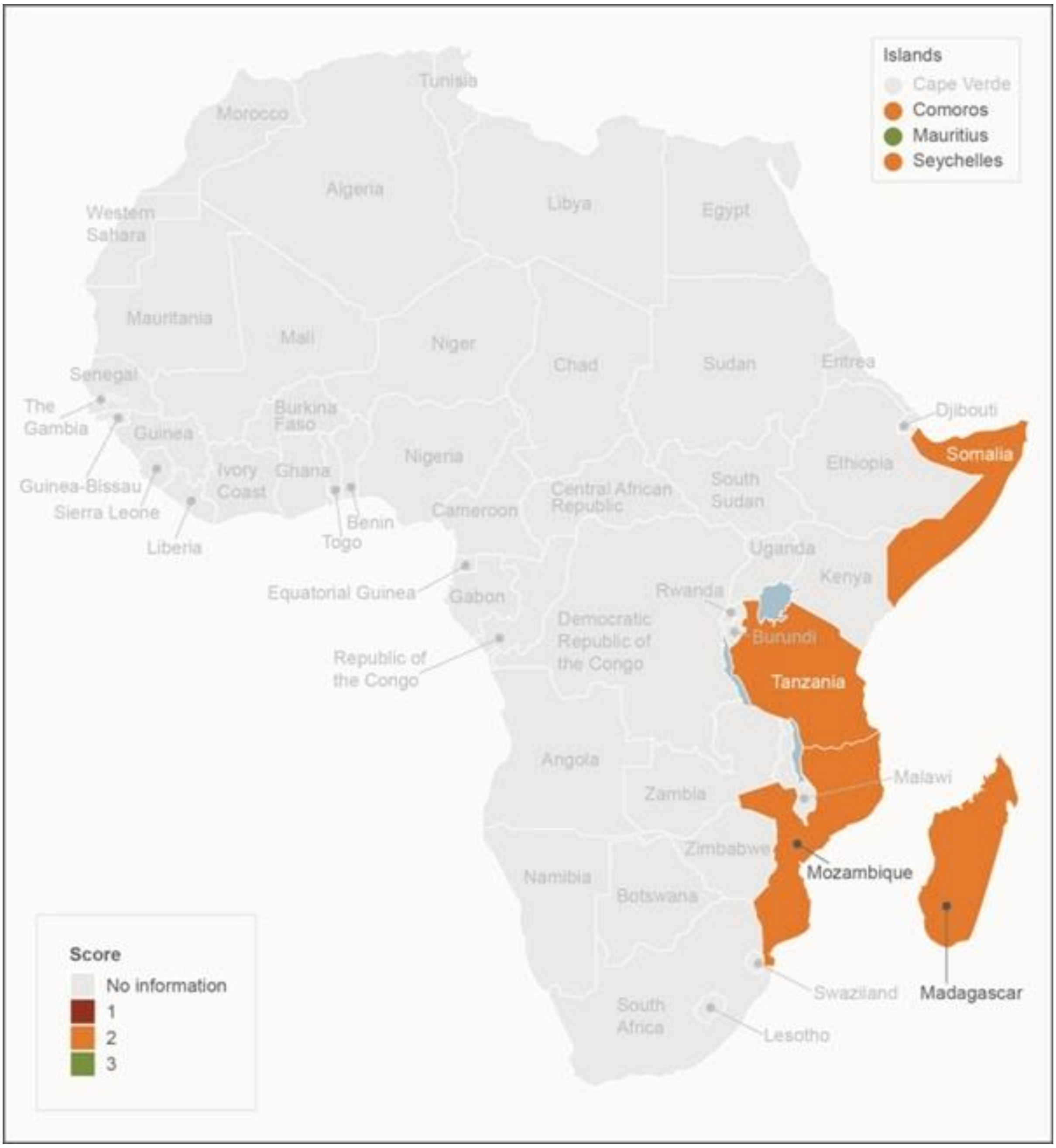


Figure 13 The effectiveness of early warning systems for cyclones in Africa



SECTION 5

The Caribbean – Overview of the current status of risk assessments and early warning systems

5.1 Introduction

Small Island Developing States (SIDS), which comprise the majority of the Caribbean, are particularly prone to weather-related hazards in all their forms: cyclones, droughts, floods and landslides. Owing to their size it often only takes one of these hazards to lead to the loss of lives and livelihoods, but also to have an adverse effect on their often vulnerable economies. Tropical cyclones are the most frequently damaging hazard for the majority of countries in this region; however, floods and droughts can pose significant challenges in many Caribbean states are also discussed below.

5.2 Floods

5.2.1 Risk assessments for floods

The results of the analytical framework shown in Figure 14 shows the effectiveness of flood risk assessments in the region. Stakeholder feedback indicated that an “effective” flood risk assessment exists for Trinidad and Tobago; however, for the rest of the Caribbean effective flood risk assessments do not appear to exist.

Flood hazard mapping in the Caribbean is highly variable. National flood hazard mapping has been carried out for Grenada; Guyana; Jamaica; Montserrat; St Lucia; St Vincent; Trinidad and Tobago (Cooper and Opadeyi, 2006; Lumbroso et al., 2011; Lyew-Ayee and Ahmad, 2011). However, the accuracy of the data available to produce these maps was often limited (e.g. maps are based on inaccurate topographic data). Little information is readily available on exposure and vulnerability of people and assets making the assessment of flood risk in the region difficult.

The Caribbean Catastrophe Risk Insurance Facility (CCRIF) has developed an excess rainfall index-based insurance product at sovereign state level in the Caribbean. However, the CCRIF does not produce flood hazard or risk maps it merely uses a simple vulnerability curve linked to rainfall intensity to assess economic loss at a national scale. This cannot be easily disaggregated to assess the impacts on the most vulnerable communities.

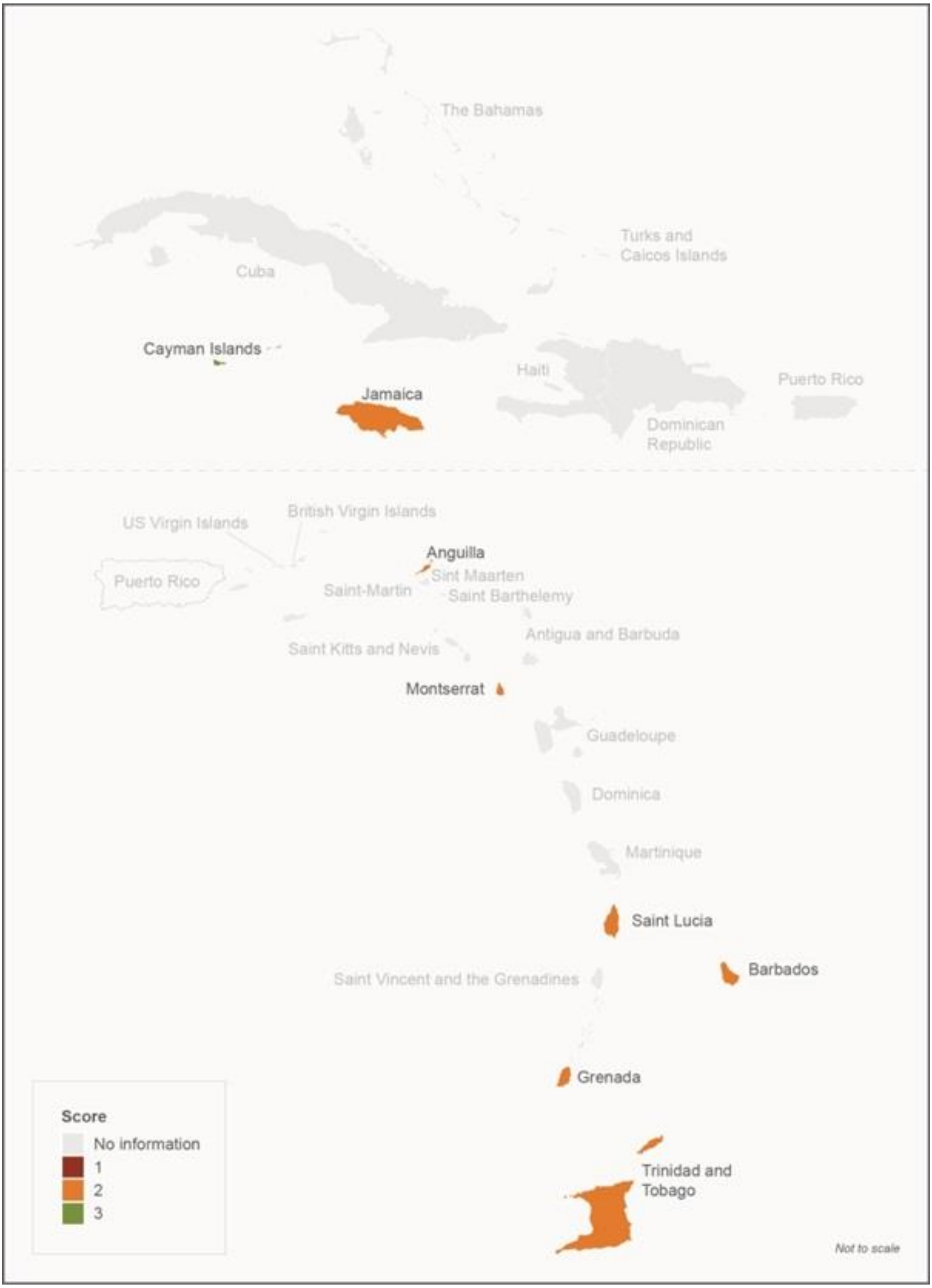
To conclude there appears to have been little work undertaken to assess the risk posed by floods in the Caribbean for either humanitarian or development purposes.

5.2.2 Early warning systems for floods

The picture concerning flood forecasting and warning in the Caribbean is variable. Floods in the Caribbean are difficult to forecast owing to the fact that, in general, the catchments are fairly small and often mountainous. This leads to flash floods that are the result of intense rainfall over relatively small drainage areas. This means that it is frequently challenging to provide lead times, (the time between issuing a warning and when the forecast flood peak is reached), of more than a few hours. As a consequence, the assessment carried out using the analytical framework shown in Figure 15 only shows a few moderately effective flood warning systems across the Caribbean.

Figure 14 The effectiveness of risk assessments for floods in the Caribbean

Figure 15 The effectiveness of early warning systems for floods in the Caribbean



Many islands do not have the capacity or the resources to provide a flood warning service. Jamaica where the first flood forecasting systems were set up in 1992, has warning systems for its larger catchments together with some community-based schemes (Haiduk, 2005); however, there is room for these to be improved. There have also been pilot flood forecasting systems implement in some catchments in Barbados and Guyana (Boyce and Whitehall, 2013), as well as web-based system for Haiti; however, these do not appear be very effective in communicating with vulnerable communities.

A comparative analysis of community based risk assessment and early warning programmes in Guyana, the Dominican Republic and Haiti has indicated the importance of embedding such interventions within viable community networks supported by trusted local government, and that such relationships can have virtuous additional benefits for example in local economic development, trust building with police and community cohesion building (Pelling, 2011).

5.3 Droughts

5.3.1 Risk assessments for droughts

The Caribbean is not often perceived to be an area that is significantly affected by droughts. However, Figure 1 shows that on a per capita basis the number of people affected by droughts in the Caribbean over the past 20 years is similar to the number in Africa and South Asia. Figure 16 shows the effectiveness of risk assessments in the Caribbean, based on the assessment using the analytical framework. Only the Dominican Republic appears to have carried out any type of national risk assessment for droughts.

In the Caribbean there does not currently appear to be a credible drought risk model that provides a measure of the impact on agricultural production or people's livelihoods.

5.3.2 Early warning systems for droughts

In the Caribbean the effectiveness of early warning systems for droughts, based on the analytical framework, would appear to be relatively limited with Figure 17 showing the Dominican Republic, Grenada and Haiti having early warning systems for droughts.

There is some on-going research into improving drought forecasting in the region (see Annex 4); however, these tend to focus on the regional scale rather than at country level. For example, the Caribbean Institute for Meteorology and Hydrology produces seasonal rainfall and temperature forecasts (Trotman, 2010). This is part of the Caribbean Drought and Precipitation Monitoring Network which helps to improve the prediction of droughts in the Caribbean. This initiative currently utilises two widely used meteorological drought indices: the Standardised Precipitation Index (SPI) and Deciles over one, two, six and 12 month time scales (Farrell et al., 2010). There is considerable room for improvement in the effective communication of drought warnings in the region and consideration of developing strategic policy for managing demand and supply of water.

Figure 16 The effectiveness of risk assessments for droughts in the Caribbean

Figure 17 The effectiveness of early warning systems for droughts in the Caribbean

5.4 Cyclones

5.4.1 Risk assessments for cyclones

In the Caribbean tropical cyclones, (generally referred to as hurricanes), are a regular occurrence in the region. Figure 18, produced using the analytical framework, shows that Cuba, the Dominican Republic and Antigua and Barbuda lead the way in terms of the effectiveness of their risk assessments. Cuba is often held up as an exemplar in the region with regards to cyclone risk assessments and warnings (UNISDR, 2004).

In the Caribbean, geospatial data relating to households and other assets affected by cyclones, or other natural hazards, are not readily available. There is Caribbean Catastrophe Risk Insurance Facility (CCRIF) that offers index-based insurance which disburses funds based on the occurrence of a pre-defined level of hazard and impact without having to wait for an on-site loss assessment. Payments are made on the basis of exceeding a pre-established trigger event loss (CCRIF, 2012c). However, the CCRIF does not produce cyclone risk maps or risk assessments and the spatial scale means that it is not possible to use the analysis to assess risk at a community level.

5.4.2 Early warning systems for cyclones

In the Caribbean the United Nations has lauded Cuba as a model of hurricane preparedness (UNISDR, 2004). Figure 19, based on the analytical framework, shows that Antigua and Barbuda, Barbados, the Cayman Islands, Cuba, the Dominican Republic and St Vincent and the Grenadines all have effective cyclone early warning systems.

In the Caribbean all hurricane forecasts and warnings are available on public web sites (except for the Turks and Caicos) and real-time media (e.g. TV and radio) are considered to be the highest priority to disseminate warning information directly to the public. In some countries (e.g. Bahamas, Cuba), a meteorologist directly appears on TV or broadcasts live on radio in case of severe weather to deliver the important and credible information.

As stated above Cuba, that has been held up as an exemplar of effective early warning systems for hurricanes by the UN. The Institute of Meteorology of Cuba has a network of some 120 climate stations, five radars and operational access to satellite pictures. Operational forecasts are supported by their own hurricane prediction methods. Cuba also utilises a system that allows the meteorological service to broadcast directly to the national TV channel (WMO, 2010c).

5.5 Landslides

In the Caribbean landslide hazard has been mapped in a piecemeal fashion. Islands such as St Lucia, and Jamaica have landslide hazard maps. There have been some community-based hazard assessment of landslides; however, there does not appear to have been any risk modelling of landslides where both the probability of the hazard and the impacts of people have been assessed.

Figure 18 The effectiveness of risk assessments for cyclones in the Caribbean

Figure 19 The effectiveness of early warning systems for cyclones in the Caribbean

SECTION 6

South Asia

6.1 Introduction

South Asia is home to more than one fifth of the world's population. Floods and cyclones account for the majority of the reported weather-related disasters in the region. However, droughts have a significant impact on vulnerable people's livelihoods especially in the arid and semi-arid regions of Afghanistan, India, and Pakistan.

In some parts of the region low temperatures, snow and blizzards can also have a serious impact. For example it is reported that in February 2008 in Afghanistan temperatures fell to a low of -30º C that resulted in the deaths of approximately 900 people (Memom, 2012).

Glacial Lake Outburst Floods (GLOFs) that occur when natural dams, normally formed of moraine, containing a glacial lake fails. GLOFs are a major hazard in parts of Bhutan, India, Nepal and Pakistan. This section concentrates on floods, droughts, cyclones and landslides because in terms of humanitarian impact these are the weather-related hazards that have the biggest impact.

6.2 Floods

6.2.1 Risk assessments for floods

In South Asia, where floods have the biggest impact on people of any weather-related hazard, flood risk mapping in Bangladesh, India and Nepal has been carried out, although in the case of Bangladesh and Nepal the communication of these assessments could be improved. Figure 20 shows the effectiveness of flood risk assessments in the region, based on the analytical framework.

In India a vulnerability atlas has been produced. This depicts flood hazard maps for the whole country as a whole, and shows the vulnerability of states to various hazards on a macro scale (Building Materials and Technology Promotion Council, 2006). It also includes a database based on the housing stock in India in 2001. This database was updated in 2011 as part of that year's census, although it is unclear if the risk assessment for floods has updated recently to include this.

In Nepal there has been a comprehensive risk assessment carried out for all the natural hazards affecting the country. In Pakistan there has been flood hazard mapping carried out for most major rivers, but this does not evaluate the social or economic risk.

6.2.2 Early warning systems for floods

In the majority of states in South Asia the catchments are large (i.e. greater than 1,000 km^2). Flood forecasting and warning systems have been established in Bangladesh and India for several decades. Various authors (see Islam et al., 2000; Mirza et al., 2003; Haque et al., 2011; Habib et al., 2012) have indicated that improvements in flood forecasting have reduced the number of fatalities from this hazard in Bangladesh and also in India.

Figure 21 shows that Bangladesh, India and Pakistan have moderately effective flood warning systems and that although early warning systems often exist in other South Asian states that there is room for improvement in their effectiveness, based on the assessment using the analytical framework.

India is set to invest in satellite-linked sensors to improve flood forecasting and it has been reported that its flood forecasting budget could increase five-fold over the next few years (Chaudhary, 2013). In Nepal and Pakistan there are flood forecasting systems in place at both national and in some cases community levels. However, the national level early warning systems in these countries do not always result in the desired response (see Fair, 2011).

Apart from Sri Lanka and Afghanistan, operational flood forecasting systems in South Asia appear to be reasonably well developed. However, there are issues with the lack of co-operation between some South Asian countries that prevent more timely flood warnings.

Figure 20 The effectiveness of risk assessments for floods in Asia

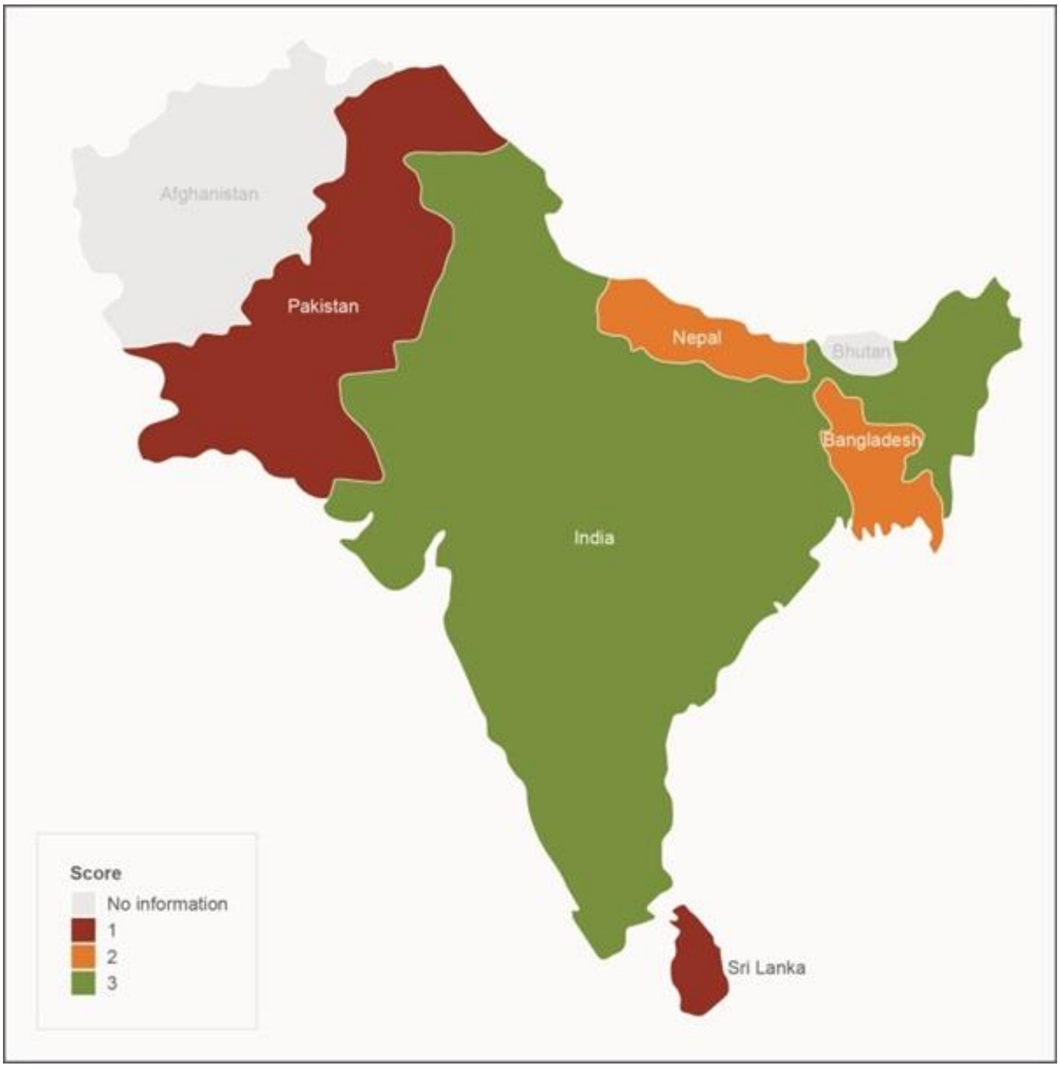
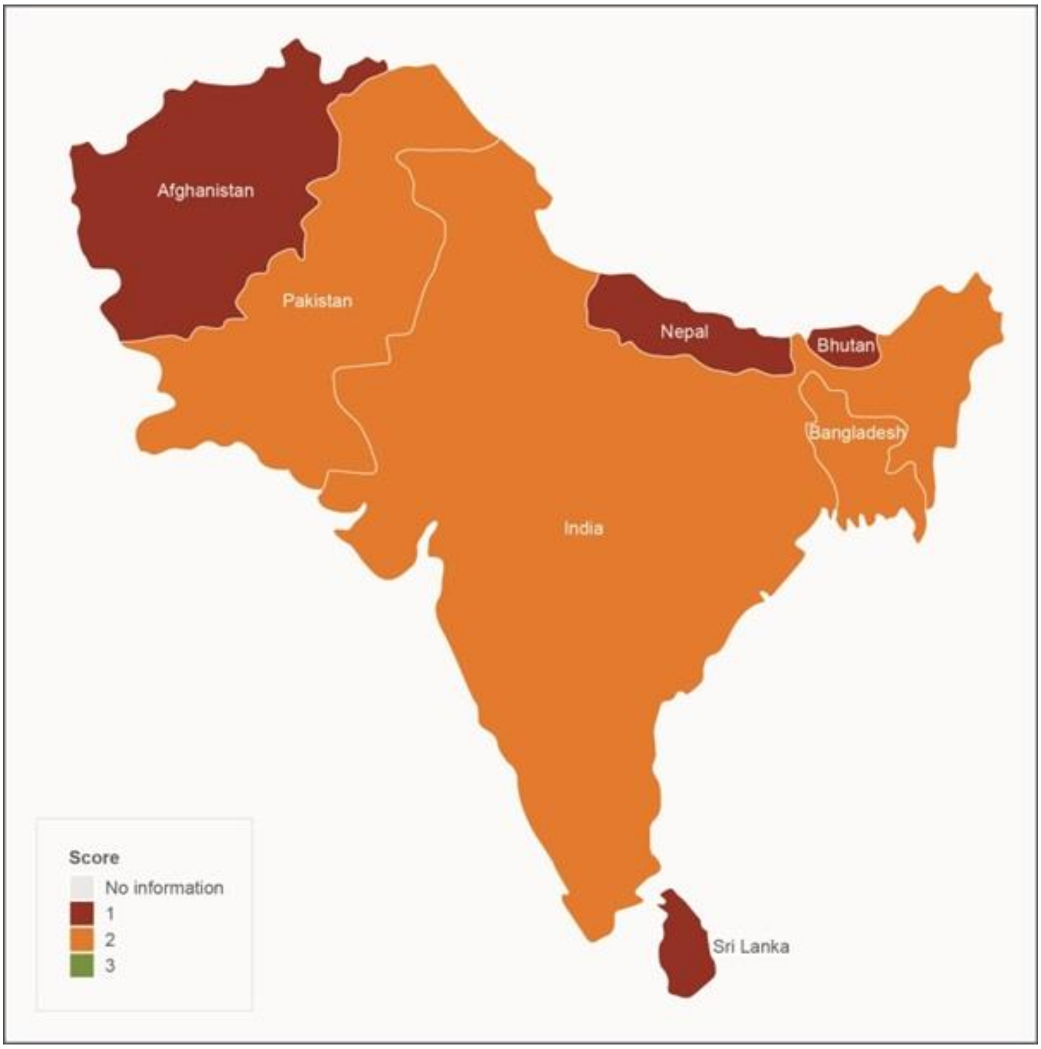


Figure 21 The effectiveness of early warning systems for floods in South Asia



6.3 Droughts

6.3.1 Risk assessments for droughts

In South Asia, as shown in Figure 22, only Bangladesh would appear to have an effective drought risk assessment and this view was based on a relatively limited number of stakeholders. In Bangladesh the Food and Agriculture Organization and the Asian Disaster Preparedness Center have led assessments of livelihood adaptation to climate variability and change in the drought-prone areas of north-west of the country. This work was designed to characterize livelihood systems, profile vulnerable groups, assess past and current climate impacts, and increase understanding of local perceptions of droughts, coping capacities and existing adaptation strategies (Ramamasy and Baas, 2007).

A report produced by the United Nations Development Programme (UNDP) in 2012 based on a survey of providers and users' experience of drought risk assessments and warning systems in Africa and South Asia found that in these regions there were very few examples of systems for drought risk assessment and the dissemination of early warning being "well established and highly regarded" (UNDP, 2012). This is reflected in the independent mapping of effectiveness undertaken as part of this study using the analytical framework.

6.3.2 Early warning systems for droughts

In South Asia drought forecasting is not as well developed as flood forecasting, despite most countries in the region experiencing numerous major droughts in the past 50 years. Figure 23 shows the effectiveness of the early warning systems for droughts in South Asia. Afghanistan, Bangladesh and India have been adjudged to have moderately effective early warning systems, using the analytical framework, with the rest of the region having drought early warning systems in place although their effectiveness is questionable with regards to reaching the most vulnerable communities.

In Bangladesh the Meteorological Department is responsible for drought forecasting; however, it does not have its own models. In India the Meteorological Department generates the short (i.e. one to two days) and long range (monthly and seasonal scale) forecasts. Although western Nepal is vulnerable to droughts, there is no operational drought forecasting system for the country (Monirul Qader Mirza, 2010). The Pakistan Meteorological Department issues drought bulletins that are available via its web site and since 2004 the number of meteorological stations has increased significantly to help strengthen the drought monitoring system.

Figure 22 The effectiveness of risk assessments for droughts in South Asia

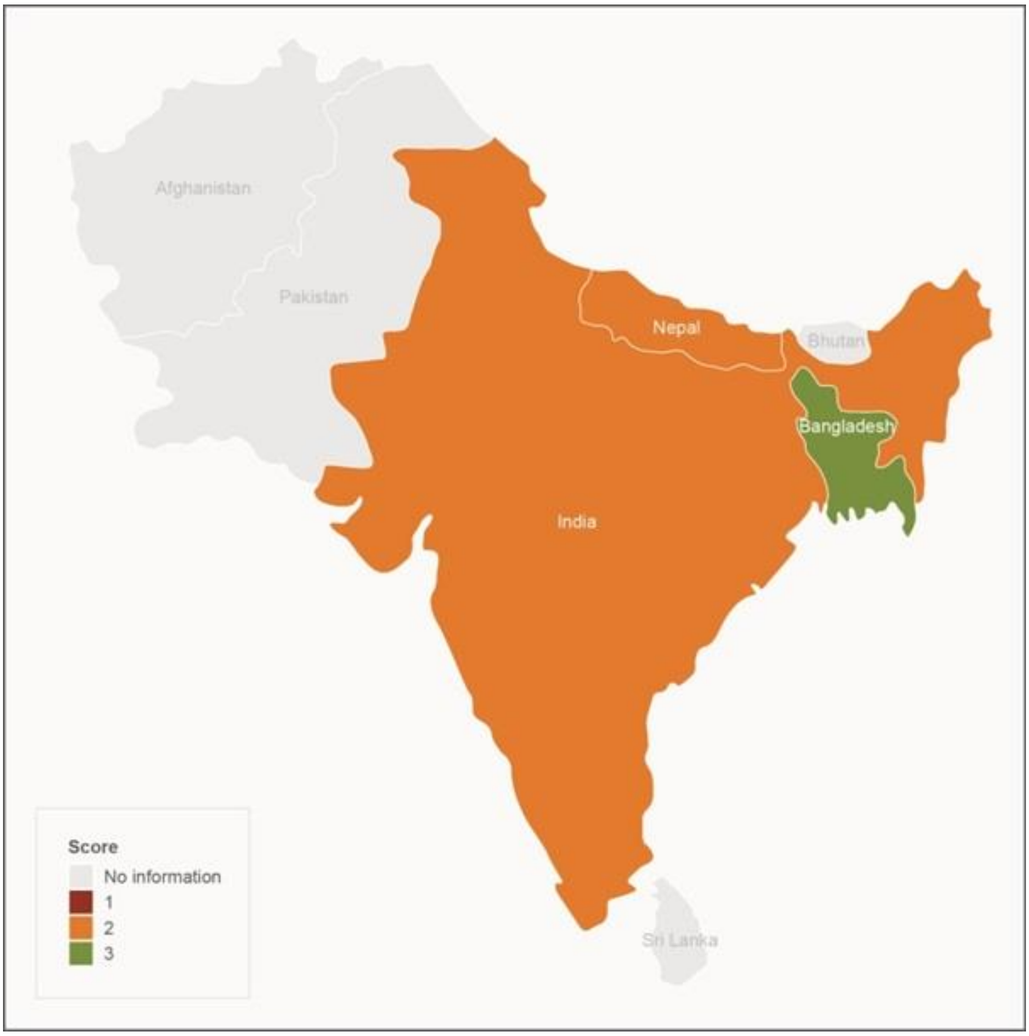
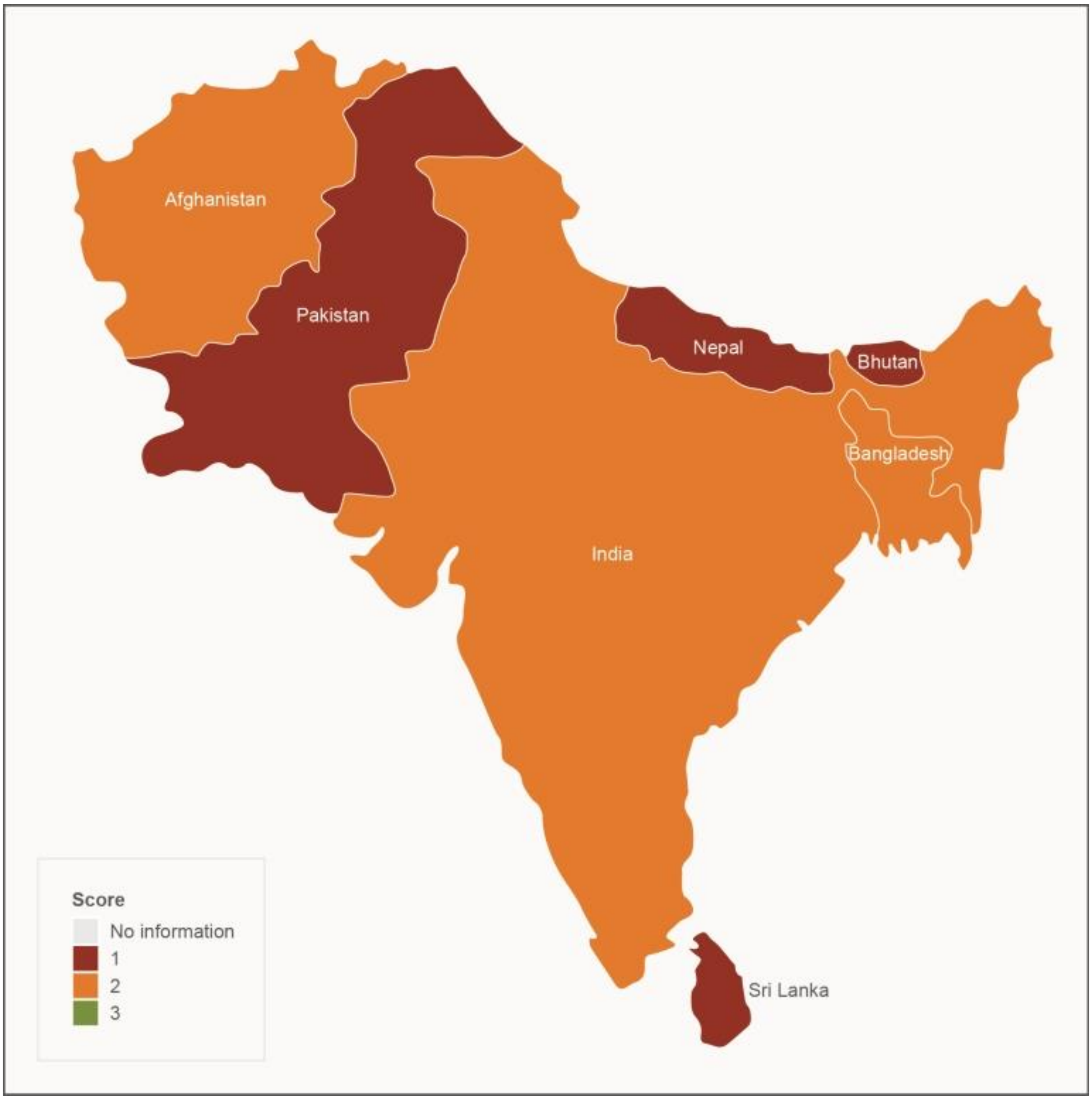


Figure 23 The effectiveness of early warning systems for droughts in South Asia



6.4 Cyclones

6.4.1 Risk assessments for cyclones

Figure 24 shows the effectiveness of risk assessments for cyclones for South Asia, based on the analytical framework. There have been some attempts to assess risk from cyclones. For example, Hussain and Singh used a GIS to assess human vulnerability to cyclones in India. The assessment took into account the potential exposure of people affected by cyclones by integrating the paths of cyclone tracks, population and poverty data (Hossain and Singh, 2003).

Also in India a cyclone risk model has recently been completed (AIR World Wide, 2013). The model combines a cyclone hazard model with a high-resolution industry exposure database for India. This contains counts of all insurable commercial, residential, and industrial properties and their respective replacement values, along with information about occupancy and the physical characteristics of the structures, such as construction type and height classifications (AIR World Wide, 2012).

6.4.2 Early warning systems for cyclones

India and Bangladesh both have been deemed to have effective cyclone early warning systems, as shown in Figure 25 as assessed using the analytical framework. This is borne out by the reduction in fatalities decreasing over the past three decades despite the exposure to this hazard increasing (see Islam et al., 2000; Mirza et al., 2003; Haque et al., 2011; Habib et al., 2012, World Bank, 2013 WMO, 2012; Shankar, 2013; UNEP, 2013a and many others).

In Bangladesh early warning systems and Cyclone Preparedness Programmes (CPP) were initiated in Bangladesh after the 1970 cyclone. There are around 43,000 CPP volunteers, stationed in the coastal districts, who are responsible for disseminating cyclone warnings among villagers via megaphones and by house-to-house contact. The number of cyclone shelters has also increased significantly (Paul, 2009). However, in Sri Lanka it has been reported that the Meteorological Department still lacks the necessary manpower and technological know-how to meet the many of the forecasting and warning challenges posed by tropical cyclones (IRIN, 2013a).

6.5 Landslides

In India a rapid assessments of the damage caused by landslides to buildings and agricultural land have been undertaken using high resolution images from Indian launched satellites (Martha and Vinod Kumar, 2013). In Nepal the risk of landslides has been assessed in a country wide assessment of natural hazards and their resulting risk (see ACDP, 2012a and 2012b for further details). There has also been some limited landslide hazard assessments carried out in Pakistan.

Compared to cyclones, droughts and floods the amount of research that has been carried out for landslide early warning systems in all three regions would appear to be relatively limited. Although, in the past decade, in Nepal landslides have resulted in the highest number of deaths of any natural hazard, there is no early warning system in place for them (IRIN, 2013b).

Figure 24 The effectiveness of risk assessments for cyclones in South Asia

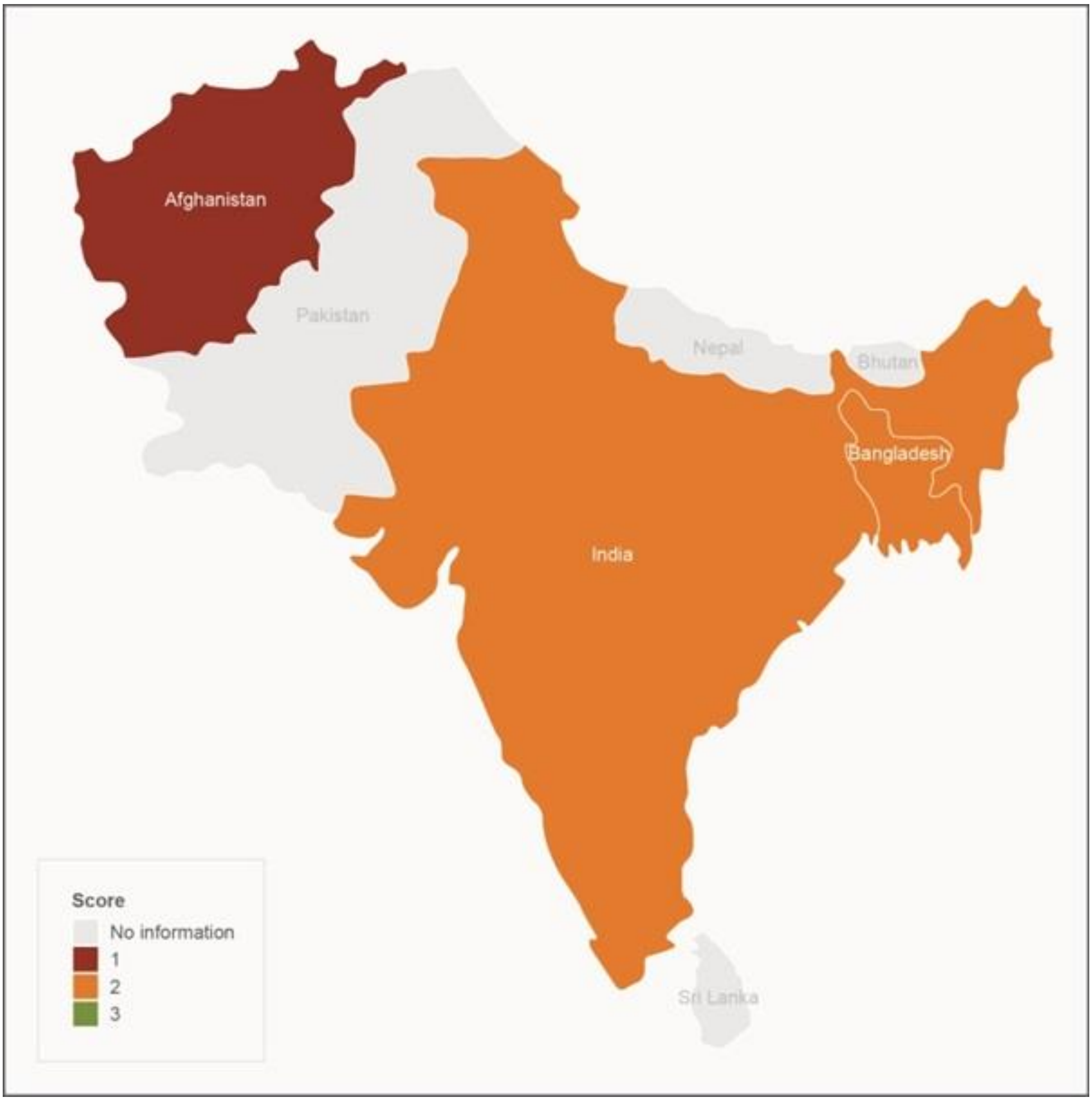
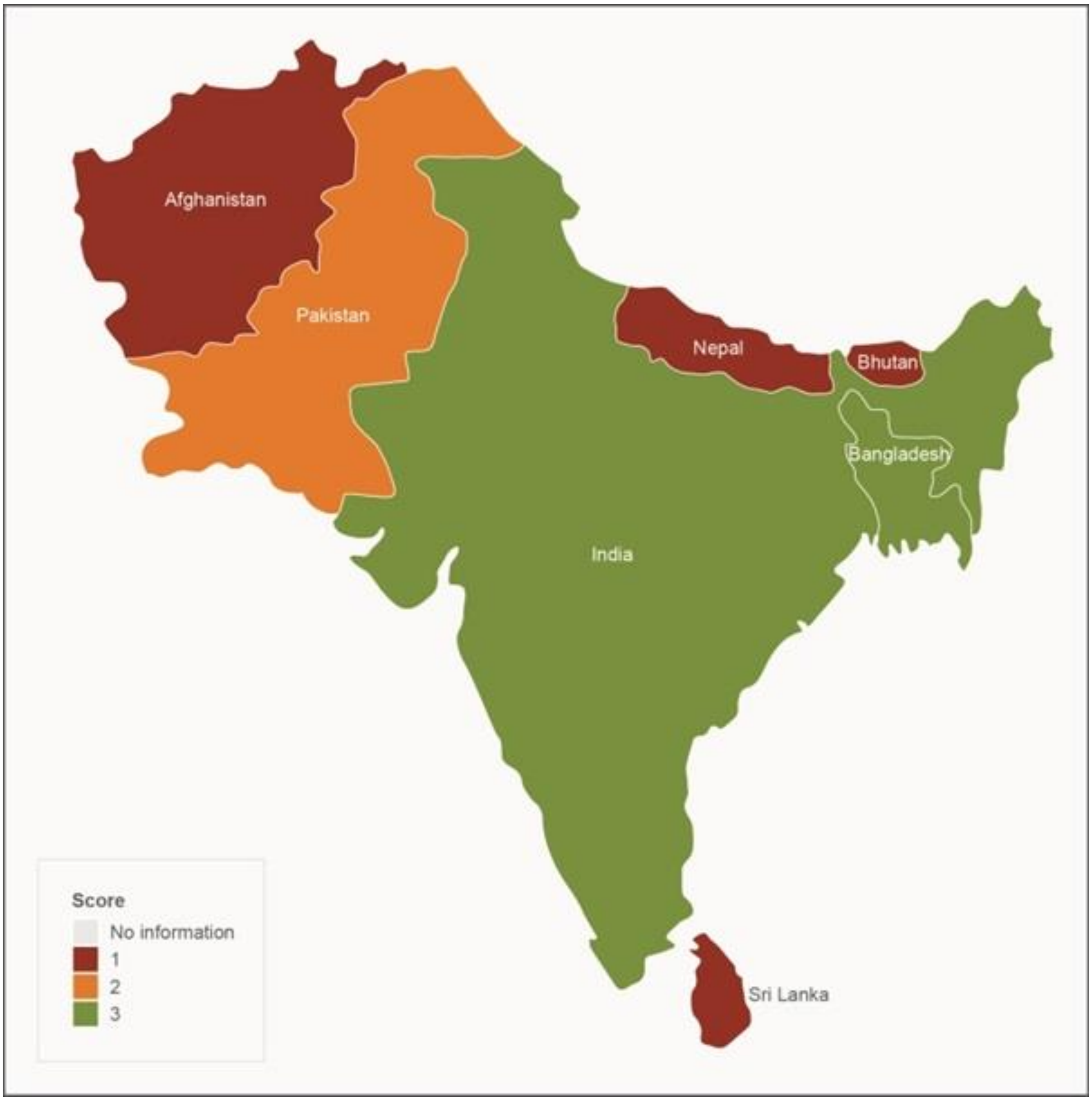


Figure 25 The effectiveness of early warning systems for cyclones in South Asia



SECTION 7

A summary of the status of risk assessments and early warning systems and cross-cutting issues

This section provides a summary of the status of risk assessments and early warning systems based on Sections 4, 5 and 6 as well as the work that is detailed in the four Annexes. Figures 26, 27, 28 and 29 provide a summary overview of the status of risk assessments and early warning systems for the main weather-related hazards in the three regions.

As indicated in these figures, the status (and effectiveness) if these systems depends upon dissemination/communication and response capacity as much as the existence, coverage, quality, spatial scale and 'skill' of risk assessments and early warning systems. There were many examples cited where early warning systems were accurate and capable of providing useful information but this was not effectively communicated or acted on. In addition, it is recognised that the skill of early warning systems for natural hazards is variable in different parts of the world and at different times of year, due to lack of data or the skill of models, so even if communication and response were effective there will be limitations to their effectiveness. This is important in the context of developing a multi-disciplinary research programme to ensure a balance between natural and social science (Sections 8 and 9).

From the work carried out a number of cross-cutting themes that emerged. In all three regions there have been a number of discrete Non-Governmental Organisation (NGO) led activities. This proliferation of actors means that there is a need not only to reach out to government organisations and agencies when building administrative systems for risk assessments and early warnings, but that there is a need to systematise this activity and provide a mechanisms for future systematisation. It seems likely that in the future more non-state actors, including the private sector, will proliferate and how they connect to government schemes and how they can reduce threats and loss amongst the most vulnerable communities does not appear to have been well researched.

A second cross-cutting theme is one of the conceptualisation of risk monitoring in isolation from development and loss data collection and measurement. Linking risk and development data provides leverage on underlying development drivers and status, and association with the production of vulnerability (including exposure and capacity); this will connect well with Hyogo Framework for Action II (HFA II). Including loss data alongside vulnerability (and development) provides a mechanism for measuring, albeit approximately, performance. This has the potential to be a very powerful analytical measure and could be used as a policy guidance tool if all the indicators were to be disaggregated; for example, by factors such gender, age and health.

Underlying the above is a need for developing the institutional architecture for data collection. This is becoming increasing important given the increasing use of crowdsourcing data from mobile phones to map risks for post-disasters. It is important that data collected by NGOs such as MapAction does not "by-pass" official government data collection routes, where these exist, otherwise these data can become lost.

A third cross-cutting issue is that currently risk assessments and early warning are generally implemented to address low frequency, high severity “catastrophic” (or “intensive”) events rather than events that result in extensive losses (i.e. minor risks that occur more frequently). The importance of ‘extensive risk’ as a break on human development has been made in the recent UNISDR Global Assessment Report (UNISDR, 2013). Extensive risk is small scale, localised, distributed and often “below the radar” of loss observation so is not taken into account in risk assessments or early warning systems. How this could be achieved is a major area of research. For example, it points to multi-level models where local government or community groups act at the extensive risk level and specialist agencies work on intensive risk.

Figure 26 Floods - Overview of the status of risk assessments and early warning systems

	Africa	Caribbean	South Asia
Risk assessments	Piece meal coverage, flood risk mapping taking into account vulnerability and exposure of people has not been widely undertaken.	Highly variable and limited availability. There is an index-based insurance product for surface water flooding; however, this is only available to sovereign states.	Vulnerability atlases are available for some countries (e.g. India, Nepal) and there are proprietary insurance products although the results of these are not the publically available.
Monitoring and forecasting systems	There is for an improvement in data collection and monitoring systems especially for lead times between 6 and 14 days.	Variable there are some limited forecasting systems in Jamaica and some community-based ones elsewhere.	There are some good systems in place e.g. forecasting systems in Bangladesh and India. There is a need for improved regional cooperation.
Dissemination and communication	Limited and requires improvement.	There is a relatively limited pilot web-based system for Haiti. However, generally there is significant room for improvement in the communication of the limited flood forecasts that are available.	Some success at national and community level.
Response capacity	Shortage of trained personnel. Some small but effective community-based schemes.	Variable, expertise based at regional centres such as the Caribbean Institute for Meteorology and Hydrology.	India's budget for flood forecasting is set to increase significantly in the next five years, although funding and technical capacity issues remain issues for other countries.

Figure 27 Droughts - Overview of the status of risk assessments and early warning systems

	Africa	Caribbean	South Asia
Risk knowledge	Some hazard and vulnerability mapping, as well as an index-based insurance system at a sovereign state-level.	Drought is not considered in many disaster risk reduction plans.	Some limited risk assessment with respect to food security.
Monitoring and warning systems	Inadequate monitoring but some progress on food security e.g. Famine Early Warning System Network (FEWSNET).	Limited monitoring and warning systems although there has been some recent progress.	Mixed, not as well developed as floods. FEWSNET operational in Afghanistan.
Dissemination and communication	Warnings do not reach the most vulnerable.	Some recent attempts to improve the communication of droughts.	Forecasts do not always reach relevant stakeholders
Response capacity	There are knowledge gaps and there is a lack of data sharing and communication is often not effective	Limited but improving.	Funding and science capacity issues. There is room for improvement.

Figure 28 Cyclones - Overview of the status of risk assessments and early warning systems

	Africa	Caribbean	South Asia
Risk knowledge	Limited.	Some index-based insurance at a sovereign state level.	Some mapping and insurance industry models.
Monitoring and warning systems	Some systems usually based on UK Met Office or Météo France products.	Operational systems in place. Cuba is seen as an exemplar in the region.	Good operational systems in place (e.g. India, Cyclone Phailin).
Dissemination and communication	Some anecdotal evidence of success in Mozambique.	Generally the progress is good.	Good examples (e.g. Bangladesh) but still some room for improvement.
Response capacity	Some good community examples.	Some good progress but there are still some states where improvements can be made.	More work on reducing vulnerability needed.

SECTION 8

Barriers to the improving risk assessments and early warning systems

Based on this engagement and the available literature this section briefly summaries the barriers to improving the effectiveness of risk assessments and early warning systems. Section 8 outlines the research gaps that were arrived at via the same means.

8.1 Barriers to effective risk assessments

It is important to realise that there are limits on how “good” risk maps for weather-related hazards can ever be made, some constraints are imposed by lack of knowledge of the hazard and others by the lack of information on the people and their livelihoods that may be affected by a hazard, others on lack of impact data with which to appraise risk reduction and response performance. In some cases the push for high quality data and technically sophisticated analysis can undermine the sustainability and local ownership of monitoring and early warning. There is a need to assess the appropriateness of risk management data systems and these may need to be multi-level in terms of data quality, for example in complex urban systems. The main barriers to improving risk assessments for weather-related hazards are detailed below.

8.1.1 Narrow focus on preparedness

Risk assessments and early warning systems that often narrowly focus on disaster preparedness fail to generate synergies with disaster risk reduction, climate change adaptation and multi-hazard assessments that convey other “in-demand information”. This is often a barrier to effective risk assessments. A more joined up approach that includes the above mentioned elements would help to focus government priority and resources, leading to greater efficiencies and better ensuring the sustainability of the system.

Stakeholders stated that one barrier was lack of use of innovative modelling techniques such as agent-based modelling[15] . These can be used to offer robust methods to simulate the autonomous decision making process relating evacuation prompted by the forecasts of hazards and how agent-based models can be used to evaluate emergency management interventions such as the location of cyclone shelters.

8.1.2 Availability of accurate spatial information especially relating to the vulnerability of people and key assets

One of the main issues in carrying out effective risk assessments is the lack of appropriate vulnerability data bases at a suitable spatial scale to make the assessments meaningful. Approximately 80% of the stakeholders that were engaged with as part of this study (see Annex 1) indicated that the lack of available information on factors that affect people’s

15 An agent-based model is a computational model for simulating the actions and interactions of “agents” which can be either individual or collective entities such as organizations or groups to evaluate their effects on the system as a whole. These have been used to evaluate the effectiveness emergency interventions for floods

vulnerability to weather-related hazards was either the “most important” or a “very important” barrier to risk assessments being effective in the three regions.

The Red Cross recently noted that to date in most low-income countries, no comprehensive, openly licensed maps of educational, cultural or scientifically relevant installations (e.g. schools, sources of water supply, sanitation, libraries) exists (Red Cross, 2013). When information is available it is often superficial and limited to geo-coordinates. It is very rarely gender disaggregated. Red Cross also states that “*the availability of community-prioritized data, particularly on a large scale, from the field would be a substantial asset in preparedness, planning and response in post-conflict and post-disaster contexts*” (Red Cross, 2013). While there is much experience of measuring vulnerability there is much less experience on how to make this measurement systematic to allow comparisons and to embed measurement within a sustainable organisational architecture. This is a major problem for rapidly changing urban contexts. Here, it may be that a clustered approach where high risk areas gain more support for detailed assessment connected to on-going community based work can sit alongside lower resolution data approaches for more formally managed urban areas.

The lack of a common approach within each region for monitoring, sharing data and using agreed methodologies for assessment of vulnerability (development and loss) can hamper timely and efficient response from communities, national governments and international partners. In many countries the institutional architecture for the systematic collection of vulnerability, development status and loss data disaggregated by gender, (and other relevant parameters e.g. age), and at a spatial scale that can inform risk reduction and response interventions is either primitive or absent, as discussed above.

8.1.3 Lack of systematic community participation

The lack of community participation in data collection and management, as well as in “early warning to action” is a major barrier. Where community participation is evident this contributes most to risk monitoring and early warning when connected to wider, government-led initiatives. Without coordination “mixed messages” can be dangerous, with coordination local specificity and independence can add resilience. The need for community engagement is perhaps greatest with regard to “extensive” risk is a barrier to effective risk assessments especially in urban areas. The implementation of participatory local hazard-vulnerability assessments and associated risk mapping can act as a strategic entry point to raising critical awareness and understanding of risk and to building relationships among different actors.

Issues raised by stakeholders included:

- A paucity of credible data at the relative spatial and temporal scales on vulnerability
- Accessibility of risk maps, and their relevance to humanitarian and developments goals
- Availability of accurate spatial information
- Lack of technical capacity to produce maps
- Lack of “embededness” of risk assessments in community context

8.1.4 Lack of accountability of extensive risks

Extensive risk from weather-related hazards can be defined as risks whose consequences are too small to be classified as major disasters. Studies of urban areas in low-income countries that took account of ”extensive risk” and ”small” disasters show that these are generally concentrated in informal settlements with floods and high winds featuring amongst the most prominent causes. Many stakeholders stated that extensive risks are often not taken into account in risk assessments for weather-related hazards. This means that the risks to the most vulnerable people living in urban areas are often underestimated.

A recent analysis by UNISDR carried out in 19 countries found that extensive disasters accounted for a small proportion of disaster mortality, but for a much larger share of damage to housing, livelihoods and local infrastructure and impacts on low income (urban and rural) households and communities. Almost all extensive risk disasters were weather-related and these accounted for 54% of houses damaged, 80% of people affected, 83% of people injured, 46% of damage to schools and 54% of damage to health facilities (UNISDR, 2011). Another barrier to assessing extensive risk in urban areas is that for urban centres in low-income countries there are a lack of data for individual urban centres and data are only available at a national national-level for urban populations.

It is also important that the "multiplier" effect of repeated risks is taken into account. For example, pastoralists in Africa may be able to withstand one dry rainy season through employing a range of coping mechanisms. However, a number of dry rainy seasons in quick succession will often reduce the effectiveness of these coping mechanisms and deplete their resilience through each successive drought.

8.1.5 Accessibility of risk assessments

In many low-income countries the accessibility to risk assessments and risk maps, if they have been carried, out is poor. In the Caribbean 100% of the stakeholders engaged via a survey (see Annex 1) stated that the lack of accessibility of risk maps to relevant stakeholders was either the "most important" or a "very important" barrier to the maps not being effective.

8.1.6 Cascading hazards and multi-hazards risk assessments

Currently most risk assessments for weather-related hazards in the three regions only identify the risk from individual hazards. The majority of Africa, the Caribbean and South Asia are at risk of more than one hazard type. There are few examples of comprehensive multi-hazard risk assessments from the three regions. The lack of assessment of cascading risks from weather related hazards, as well as the joining up of primary, secondary and tertiary hazards was felt by stakeholders as being a barrier to building the resilience of vulnerable communities in low income countries.

The approach used to assess risk from individual hazards generally varies between different countries. If multi-hazard risk assessments are carried out then they usually employ a simple method of summing the risk from each of the hazards. This is the simplest method of assessing the risk from multiple hazards. However, this approach does not account for the inter-linkages between hazards or take account the impact of "cascading hazards", the importance of which was highlighted by the Japanese earthquake and tsunami in March 2011. In assessing overall risk it is also important to assess temporal changes in vulnerability during successive hazards (e.g. the destruction of properties as the result of a flood will make communities more vulnerable to hazard events such as hurricanes).

8.1.7 Accessibility to Information and Communications Technology (ICT)

Although over the past five years the access of people in low income countries to Information and Communications Technology (ICT) such as mobile phones and the internet has increased almost exponentially, many stakeholders stated that one barrier was that disaggregated data on access to technology do not appear to be widely available. A study carried out in 2010 on the gender assessment of ICT access and usage in Africa found that there inequalities in access to ICT related to gender, income, the urban/rural divide and education (Gillwald et al., 2010). More disaggregated information on the access of different stakeholders to ICT was believed by stakeholders to be necessary. It is also important to consider what types of information can and cannot be accurately conveyed via SMSs and other forms of ICT.

8.2 Barriers to effective early warning systems

The main barriers to improving the effectiveness of early warning systems are summarised broadly in the sections below:

8.2.1 The effectiveness of the communication of warnings and risks

The International Risk Governance Council (IRGC) defines risk governance as "*the identification, assessment, management and communication of risks in a broad context. It includes the totality of actors, rules, conventions, processes and mechanisms concerned with how relevant risk information is collected, analysed and communicated, and how and by whom risk management decisions are taken*" (IRGC, 2010). This section deals with the communication of risk and early warnings.

The successful communication of early warnings and risks to initiate the desired response in the recipients is one of the biggest barriers to the effectiveness of early warning systems. The stakeholders indicated that they felt the main barrier to the lack of effectiveness of early warning systems lay within the "last mile"; that is, raised awareness of early warning systems, and making the warnings relevant to vulnerable communities' livelihoods.

For example two-thirds of stakeholders in Africa, engaged as part of this study, indicated that although early warning systems exist for drought, an overwhelming majority stated they are not effective in reducing loss of life. One of the reasons given for this is that the warnings are not being effectively communicated, especially to the most vulnerable sectors of society.

The challenge of effective communication of risks is not solely confined to low-income countries; however, in these countries the task of effective dissemination is often increased where there are language barriers, high levels of illiteracy, inadequate infrastructure, a lack of access to phones, radios or televisions, and the beneficiaries are either geographically remote, scattered or mobile (e.g. pastoralist communities in parts of Africa). The level of technical information in some warning can also act as a barrier to potential users.

The capacity to disseminate warning messages effectively at a local level often remains a significant barrier, and there also exists uncertainty about which dissemination methods are most appropriate and cost effective under which circumstances. National or sub-nationally developed warning systems are not always appropriate for, or applicable to, local communities. Without appropriate contextualisation, warnings may not prompt an appropriate response. One challenge to effective warnings relates to threshold levels of "danger" and how such thresholds will be interpreted by beneficiaries. The threshold levels and warnings will be dependent on people's livelihood and sometimes be different for diverse cultural groups living in the same at-risk areas.

There are also issues of making decisions under uncertainty. Increasingly long-term forecasts for both floods and droughts utilise probabilistic forecasts based on multiple ensembles. How these probabilistic forecasts are used to make decisions is often challenging, as is the way in which different sets of stakeholders respond to probabilistic information and methods by which they can be communicated. Even in high income countries research has shown that probabilistic information can act as a barrier to effective communication (Lumbroso, 2009).

Warning requirements of Kenyan farmers
A recent survey of small-scale farming communities in Kenya found that 74% of the 401 correspondents rated the weather and climate information that they received as somewhat useful. This is because the forecasts were often not communicated in appropriate language and the forecasts information was formulated on a much wider spatial scale than could be used by them. This mismatch between forecasts and end user needs can undermine trust in the organisations that are providing the forecast.

8.2.2 Capacity and funding

The lack of capacity (i.e. infrastructure, organisational and technical) within governmental and Non-Governmental Organisations and ineffective collection and management of information can slow government receipt of important "danger signs" and also delays subsequent analysis. These barriers can result in a lack of trust, credibility and reliability of the figures generated. The role of local knowledge producers is at a very early stage of consideration in many countries and currently the support for them is minimal. There is a need to improve the understanding of how local information can support and strengthen scientifically sourced early warnings and risk assessments.

In Annex 3 several of the case studies that were carried out in the three regions underlined the fact that there are a number of early warning systems that are reliant on external specialists for the technical support and maintenance of software, monitoring instruments and telemetry. These components are vital for data collection, forecasting and dissemination. This reliance on external experts can be a significant barrier to the early warning systems' sustainability. It is key that technical competences are developed and maintained through training to ensure early warning systems' effectiveness and sustainability. It is also important that early warning systems, that are implemented, are financial sustainable.

8.2.3 Data collection and management

Poor data management processes can result in limited stakeholder participation, a lack of data uniformity, and limited integration of relevant data. This is a problem within public sector agencies and increasingly through a lack of information sharing and cooperation between the private sector, civil society and public sector actors engaged across all scales from local to global. A recent report by the Global Facility for Disaster Reduction and Recovery (GFDRR, 2013) stated that "*countries already have existing stocks of data that remain latent, inaccessible even to other ministries and municipalities because they are in forms that prevent them from flowing freely. They are blocked by technologies that lock data into proprietary ecosystems, stoppered by policies that prevent release beyond small groups, or simply fragmented into bureaucratic silos that require significant investment to assemble back into a whole picture*" (GFDRR, 2013).

Many stakeholders stated one significant barrier was the lack of initiatives to "rescue" and digitize historical data (e.g. hydro-meteorological data) to improve data available . Other barriers mentioned were a lack of methods to optimize hydrological monitoring networks and to maintain sustainable, national hydrological monitoring programmes

Rapid urbanization is a feature of many low-income countries in the three regions. In many low-income countries the growth in urban populations has outstripped the growth in Gross Domestic Product (GDP). This increase in exposure and vulnerability can mean that a historical understanding of the risks is not necessarily a good guide to the future. Existing stocks of data, where they exist, related to a country's infrastructure and the vulnerability of its population will need to be updated rapidly.

Few governments in low-income countries have the resources to collect existing and new data, and combine them into a form that can be useful in assessing risks from weather-related hazards. This work must be a collective effort, engaging governments, civil society, NGOs, the private sector and individuals. The Global Facility for Disaster Reduction and Recovery has produced a draft field guide on open data programmes and management aimed at building more resilient societies. However, this is only an initial step and data management still remains a major barrier to effective early warning systems and risk assessments in most of Africa, Caribbean and parts of South Asia.

8.2.4 Coordination

Ineffective coordination can be a significant barrier to effective early warning. For example in Sudan there are some 20 organisations involved in supporting different aspects of early warning systems. Similarly in the Horn of Africa there are numerous government, Non-Governmental Organisations and international agencies involved with forecasting droughts and famines. There is often little evidence of a systematic framework to direct, guide or coordinate these organisations. Where coordination of early warnings is weak it is often the case that decision-making is fragmented and accountability is diffused.

In India different agencies issuing warning for different hazards, even though they are often interrelated. Stakeholders consulted as part of this study indicated that the dissemination of warnings by different Indian agencies often leads to ineffective communication and confusion amongst the intended beneficiaries. Conflicting warning messages to stakeholders not only leads to misunderstandings but can also result in the intended beneficiaries disengaging from early warning system.

8.2.5 A lack of monitoring and evaluation of early warning systems

There is often a lack of systematic monitoring and evaluation of early warning systems. The effectiveness of any warning system can be improved through a regular evaluation process, taking into account effectiveness at community, local and national levels.

For example, there have been a number of evaluations of the famine early warnings for the crisis that developed in the Horn of Africa in 2010/2011. Bailey reports that famine early warning systems have a good track record of predicting food crises but a poor track record of triggering early action (Bailey, 2013). This is also some times the case with flood forecasts in large catchments (e.g. the 2000 floods in Mozambique).

In recent years there have been significant improvements in the forecasting systems for all types of natural hazards. Bailey predicts that continuing technological and methodological advances in forecasting systems may mean the gap between early warning and early action is set to widen (Bailey, 2013). Bailey postulates that this is because "*the long lead times offered by famine early warning systems provide the opportunity for decisive early action, but also the opportunity for prevarication, delay and buck-passing. This disconnect persists despite major improvements in the sophistication and capabilities of modern systems*" (Bailey, 2013). This means that effective monitoring and evaluation of early warning systems could become even more important in the future.

8.2.6 Availability of appropriate data and monitoring systems

Developing an effective early warning system is challenging where there are a lack of data collection and insufficient coverage of the monitoring system. The paucity of high quality data to inform forecasts and the dearth of monitoring equipment was seen as the most important barrier to the effectiveness of early warning systems as was the dearth of monitoring networks by over 70% of respondents to an internet survey carried out as part of this study (see Annex 1).

A recent report by the World Bank by Rodgers and Tsirkunov stated that main barriers to adequate monitoring networks in low income countries were:

- The lack of government and development agencies understanding of the value of meteorological and hydrological monitoring networks, as well as why they should be maintained
- Inadequate provision for training, on-going maintenance, consumables and continuing technical support
- An uncoordinated approach to hydrological and meteorological monitoring projects from donors

Massive underfunding has led to the deterioration of existing networks. A lack of modern equipment, poor quality services, a lack of trained specialists and insufficient research and development (Rodgers and Tsirkunov, 2013). The World Bank considers that the modernising of national hydrological and meteorological monitoring networks is a high value investment in low-income countries because of the potential benefits to societies. For example, improvements in monitoring networks could significantly improve seasonal forecasts for the Sahel and the Horn of Africa, increase lead times for floods in large river basins and provide nowcasts (i.e. forecasts with a 0 to 6 hour lead time) for flash floods in all three of the regions.

8.2.7 Governance and political obstacles

Poor governance and political obstacles can hinder the effectiveness of early warning systems. This is often the case where there are conflicts, weak governance, or corruption. In these situations these barriers may place restrictions on data collection, analysis, as well as information sharing. In situations of political interference or corruption, or where there is a lack of trust in the credibility, objectivity and reliability of assessment, the legitimacy and acceptance of the system can be undermined. The recognition of extensive risk unlocks additional challenges for governance where the responsibility for monitoring and warning may not be clear. For extensive and intensive risk there is a very limited culture of monitoring and innovation, pointing to a gap in dominant organisational structures and risk governance regimes.

8.2.8 Trans-boundary issues and remote sensing

Many stakeholders that were engaged with as part of this scoping study emphasised the need for improved cross-border cooperation as a barrier in improving downstream flood forecasts. In many international river basins in Africa and South Asia there would appear to be very limited sharing of data across international borders for hazards such as floods, which limits the lead time that downstream countries can achieve in their warning services. Stakeholders noted that there was scope for research into the use of remote sensing technology to monitor upstream water levels.

For other hazards the dearth of the use of web-based platforms to share data or relevant experience and cooperate with other countries or regions facing similar early warning and risk management problems, impede the sharing of best practices and innovations was also mentioned. Stakeholders mentioned that barriers existed to cost-effective, easy to use platforms to support data assimilation, real-time access to data and supports multiple stakeholder engagement and interaction.

SECTION 9

Research gaps

9.1 Introduction

Table 6 provides an overview of the weather-related hazards for each of the three regions where further research is required. The prioritisation of the hazards was based on the following:

- The humanitarian impact of the hazard in terms of the total number of people affected.
- The effectiveness of the risk assessments and early warning systems that have been implemented previously, based on the analytical framework and stakeholder engagement that have been undertaken as part of this study

Research priority	Africa	The Caribbean	South Asia
Highest	Droughts	Floods	Droughts
	Floods	Droughts	Landslides
	Cyclones	Landslides	Floods
Lowest	Landslides	Cyclones	Cyclones

Table 6 An overview of the weather-related hazards for each of the three regions for which further research is required

This report focused on these major hazards but stakeholders have also raised other weather related hazards that are also important and may warrant further research including fire, heat-waves, air pollution episodes, vector and water borne diseases and Glacial Lake Outburst Floods (GLOFs).

Although in South Asia cyclones and floods have a large humanitarian and economic impact there is evidence to suggest that the research that has already been undertaken has been effective in reducing both humanitarian and economic impacts. In South Asia the research on both risk assessments and early warning systems for landslides is limited although in countries like Nepal the number of fatalities as a result of this hazard has been significant and they also have an effect on people's livelihoods through a loss of transport routes, livestock and farmland.

Tropical cyclones in the Caribbean have by far the biggest humanitarian impact and there has been significant progress made in reducing their humanitarian impacts. Whilst there are still many improvements that can made the impacts of floods and droughts in the region, (as shown by Figure 1), are significant and relatively speaking there has been much less research carried out on these hazards than for cyclones.

It should be noted that the analysis underlying this assessment is based on intensive and direct losses, the picture for extensive risk and also when indirect "knock-on" losses are factored in may be different.

9.2 Details of the research gaps

This section provides an overview of topic areas, where although research may have already been carried out there is a need to carry out further work to improve the effectiveness of risk assessments and early warning systems for weather-related hazards. These gaps are briefly described below.

9.3 National level research priorities

9.3.1 Funding issues

Research is needed to analyse ”fit for purpose” funding mechanisms and priorities for early warning systems and risk assessments to ensure that financing is sufficient, targeted to where funds are most effective, and financed in a way that is both predictable and sustainable. This could include consideration of if, and how, contingency and response budgets can be realigned to support early warning.

9.3.2 Governance issues

Areas related to governance that need to be explored include:

- How to overcome early warning systems governance and management challenges including:
  - How to institutionalise and hand over successful community pilots to government?
  - How to include accountability mechanisms into early warning systems to improve effectiveness?
  - How to optimise community level early warning system governance structures and mechanisms to ensure sustainability and true community ownership?
- How to improve the link between early warnings and early actions, in particular issues related to effective “trigger levels” or indicators to prompt timely decision making, response and in some cases release of contingency funds for a range of different stakeholders including governments, donors and other agencies?
- In circumstances of poor governance, lack of political support or conditions of conflict, what early warning systems and risk assessment techniques are the most effective, and what actions can be led at the community level?
- How can partnerships be enhanced to improve early warning systems at regional and nation levels? How can collaboration between scientists, government institutions, NGOs and communities be effectively brokered?
- What can be done to improve trans-boundary and transnational collaborations and information sharing? This is especially the case for large river basins (e.g. the Zambezi, Ganges). How can recent and future improvements in remote sensing technology assist with these challenges?

9.3.3 Monitoring and evaluation of risk assessments and early warnings

In order to optimise early warning systems and risk assessments for weather-related hazards it is important to be able to monitor and evaluate their effectiveness and impact. This is an area for trans-disciplinary collaboration. For example Non-Governmental Organisations (NGOs) can help scientists to identify appropriate impact outcomes and indicators, and scientists can help NGOs (and ultimately communities) develop a more valid and reliable monitoring and evaluation system for early warning systems and risk assessments.

There is a need to promote an iterative risk management approach to early warning systems and risk assessments, ensuring that the evaluation of major events translates into improvement. There is a need for accountability within the humanitarian sector to monitor and evaluate interventions and take appropriate steps to improve performance and their work. Research is needed as to how this can be achieved effectively.

In terms of research priorities one approach would be to reconceptualise risk monitoring and early warning not as stand-alone and increasingly technologically driven elements of risk management, but as socially determined (i.e. user driven) elements of a holistic cycle of risk management from monitoring through risk reduction to response asks new questions of existing services and programmes:

- How can we better monitor the outcomes of each step in the risk management cycle and interactions between phases to improve performance?
- What governance contexts are best suited to implementing and holding to account holistic approaches driven by social need before technological innovation?
- How can risk monitoring, analysis and early warning to action be tailored to the needs of different user groups, from national financial managers to economic sectors, social sector actors and individual farmers at risk or local government? Each has different vocabularies, risk tolerance and mandates and this needs to be factored into systemic risk monitoring systems
- How can approaches be developed that ensure that investments made to enhance risk assessments and early warning systems are appropriately informed by relevant scientific understanding of risks?
- Systemic risk monitoring opens scope to go beyond preparing for direct impact and provides opportunities to connect risk associated with natural hazards to economic, political and other systemic risk analysis. This is appropriate for national, business and local stakeholder decision-making in a context of climate change and rapid development and social change.
- Systematic risk analysis is best placed to reflect trends for integration in risk drivers for policy measurement tools, such as the proposed Sustainable Development Goal on resilience that would incorporate conflict, climate change adaptation and disaster risk reduction perhaps amongst food and water security. Work that can provide an informed analysis for the policy and practice impacts of this aggregation of fields, plus the practical challenges of operationalization would be value beyond disaster risk management.

9.3.4 Issues related to people with disabilities and the most vulnerable in society in low-income countries

Generally there is a need to better understand how different hazards impact different social groups. The elderly, disabled and socio-economically disadvantaged are often more vulnerable than other members of society. A World Health Organization (WHO) report on disability estimates that people with disabilities constitute 15% of the world's population and up to 80% live in low-income countries (WHO, 2011). More than half a billion people with disabilities live in countries often affected by conflicts and natural disasters (Atlas Alliance & CBM, 2011). Key areas that need to be addressed are:

- How can the factors relating to people with disabilities be included in disaster management policy and governance mechanisms in low-income countries?
- How can the needs of persons with disabilities addressed in early warning and risk reduction for weather-related hazards? People with impaired mobility (including the

elderly, pregnant women and young children) are often not addressed by early warning systems and risk assessments which are a key part of emergency planning

9.5 Research priorities related to data, information and methods

9.5.1 New low-cost sources of information on hazard, vulnerability, exposure and loss

Recent research carried out has found that disaster response and relief efforts are becoming more dynamic and decentralised with the development of web-based geospatial technologies (Kawasaki et al., 2012). A major issue in low-income countries is the lack of low-cost sources of information that can be used for the assessment of risks. The creation of geospatial data sets in low-income countries via the use of crowdsourcing is not only an opportunity to help emergency response efforts, but also to help with long-term planning, including climate change adaptation. However, there needs to be further research into:

- How effective is the information that is generated by crowdsourcing in reducing risk?
- How can the data generated be used by national and locally based government organisations?
- Sustainability issues related to low-cost sources of data and information need to be researched including:
    - Data duplication
    - Data fragmentation, for example, multidisciplinary analysis requires data from across specializations; however, these data are often segmented into 'silos
    - Data access and availability

9.5.2 Improvements in climate modelling to improve early warnings and risk assessments

There is still a need to carry out further technical research to improve climate models for the three regions. For example, there is a widely acknowledged research priority to facilitate a step change in the understanding and representation of the South Asian monsoon in order to improve climate prediction over seasonal to decadal time-scales. This other research to improve climate modelling could encompass:

- **Improved prediction of the variability of ocean temperatures and teleconnections** Considerable international focus has been placed over the last decade on research to improve model predictions of the El Niño/La Nina (ENSO) events that are very influential on rainfall over Africa and other regions. However, less attention has been paid to prediction of models of sea-surface temperature (SST) variability in other ocean basins that can be equally important. The variability in the Indian Ocean and tropical Atlantic SST variability can, in some circumstances, dominate influences on East Africa and West Africa respectively. The Atlantic and Indian Oceans are also important for Caribbean and India. The performance of monthly-to-seasonal predictions in these regions is well below that for ENSO and a comparable effort now needs to be made to improve SST predictions in these ocean basins to further improve capability for early warning of drought and flood events over Africa. Improved predictions of SST variability are not sufficient; however, the models response in representing the remote impacts (i.e. teleconnections) also need to be improved
- **Improved representation of convective processes** Convective systems are the key rain bearing systems for Africa. Convective systems have lifetimes of a few hours; however, they can persist for longer when conditions allow growth of very

large convective cells. Correct representation of these processes and their links to the larger scale circulation is essential for realistic simulation of typical temporal variability in rainfall and thus to the capability to predict risks of prolonged dry spells or periods of heavy rain and other high impact events.

- **Intra-seasonal predictability** Considerable progress has been made in advancing research and the use of predictions of the onset of rainy seasons and in assessing potential for predictions of dry spell and heavy rain frequencies. These sub-seasonal characteristics are of prime importance to vulnerable stakeholders involved in agriculture and many other sectors.
- **Observations** For adequate monitoring the hydro-meteorological network needs urgent development, particularly in Africa. Monitoring products, developed to meet users' demands (e.g. for drought monitoring), need further development.
- **Downscaling** The downscaling of seasonal forecasts from regional climate models to provide greater geographical detail is still an area where much research is needed to improve the benefits delivered and establish methodology that could be adapted for real-time use

The benefits could include:

- Extended flood forecast lead-times through improved integration of numerical rainfall prediction and satellite observations with flood forecast models
- Improved forecasts of intra-seasonal variations such as active/break spells of rainfall within the monsoon season could have significant impacts on various activities. For example, extended break spells would imply an increased requirement of water for irrigation purposes
- An improvement in the skill of seasonal and intra-seasonal forecasts both for Africa and the South Asian monsoon to help to improve planning for droughts and flooding at national and district scales

9.5.3 Improved flood risk assessment and early warning of floods

Methods for hydrological, hydraulic modelling, risk assessment and early warning systems are well established and have improved significantly in some technical areas, such as the use of faster gridded modelling of two-dimensional shallow water flows. However, there are still a number of research questions that are relevant to data sparse regions and improving risk assessment and early warning, particularly for Africa and the Caribbean, including:

- How can the accurate elevation data, extreme rainfall estimates, flood flows, extreme sea level and information on defences and vulnerable communities be rapidly assimilated in data sparse regions? How can proxy data, such as historical flood extents and local knowledge of flood depths be used to build up a better picture of flood risk? What roles can global scale modelling (Pappenberger et al., 2013) and remote sensing play in improved flood warning systems? (See below).
- How can flood forecasting and early warning systems make use of medium-ranged forecasts (i.e. lead times between five and 15 days)? How could this information be used by decision makers?
- River flow forecasts extending six months into the future can project water availability for agriculture, public water supply, hydropower and other uses. There is a need to assess how the skill of these forecasts can be improved using recently available remotely sensed data sets.
- Can the integration of flood models and behavioural agent-based models be used to evaluate emergency management interventions such as the location of cyclone shelters, the timing of warnings and the management of evacuation routes for flood, cyclone and tsunami emergency planning?

Further research emphasis is needed on supporting the operational activities of the civil protection agencies during an emergency that results from weather-related hazards. Loss-of-life and evacuation models for emergency management have the potential to inform civil contingency planning and flood event management; this would assist a wider assessment of emergency plans. Similarly a better understanding of how potential failures of critical infrastructure (e.g. access routes to isolated, vulnerable communities) that is exposed to a weather-related hazard and the cascade of consequences can be modelled so that civil contingency planning can explore the full extent of an emergency.

9.5.4 Use of remote sensing data in improving early warning systems and real-time risk assessments

Most of the world's river catchments are poorly gauged or completely ungauged. There is a requirement to research the use of how remote sensing data can used to improve forecasts. Globally and freely available space-borne data can provide very relevant contributions, especially in low-income countries, and can remove, for example, an important obstacle currently preventing the application of hydrological models to make global and regional hydrological predictions. Research questions include:

- How can new remote sensing techniques be used to monitor weather-related hazards and support relevant hazard, vulnerability and risk models?
- Do new satellite sensors offer improved information products that can be integrated into risk assessments and early warning systems?
- How can sufficient and cost-effective ground-truth information be collected against which remote sensing algorithms can be validated and further improved?
- The UN Economic Commission for Africa argues that having timely access to remote sensing data is a powerful tool for regional sustainable development and disaster reduction. However, issues related to access, costs and local interpretation can act as barriers to the use of these data. These are issues that need to be researched

New data sources, such as remote sensing in combination with latest field-based observation methods (e.g. wireless sensors), are also triggering additional training needs in particular in the low-income countries.

There is a paucity of observational data, particularly in Africa. One approach that could be researched to supplement observed information to construct hazard maps is to mine the climate model retrospective forecasts (hindcasts) that are generated as part of the standard calibration of seasonal forecasts. For example, a 20 year hindcast run with a 12 member ensemble would give 240 realisations of climate. This could be used to build up maps of climatology for various hazards.

9.5.5 Modelling of the risks from multi-hazards

Many stakeholders argued that the research on extreme weather-related hazards needs to be set in a multi-hazard framework for several risk sources, which may be coincidental, conjoint or cascading, taking a "whole systems" approach to the physical, environmental, ecological and social systems, and their interdependencies and interconnectivities. Research priorities include:

- The development of suitable methods for each of the three regions to carry out multi-hazard risk assessments that are particularly focused on the most vulnerable but which can be scaled up to a sub-national and national scale so that they can be used by policy makers

- Studies into ‘cross-hazard’ dependencies and interactions among hazards, exposure, vulnerability, and multi-hazard risk management at national and sub-national scales
- Examination of the policy context for risk management and the degree to which multiple hazards are recognised and addressed in an integrated manner

9.5.6 Integrating early warning systems with risk assessments

The Famine Early Warning System Network (FEWSNET) integrates early warnings of droughts with people’s livelihoods to allow a clearer understanding of how vulnerable communities are to certain drought events. The strength of this analysis is in understanding the livelihood patterns of all wealth groups together with their interactions and interdependencies. There is still further research required to integrate early warning systems with risk assessments (in terms of people’s livelihoods) and how the most vulnerable groups cope with a weather-related hazards. There is a need to research the applications of forecasts for weather-related hazards across a large number of cutting-edge research fields and novel methods to post-process weather forecasts to make them suitable for applications are required.

9.5.7 Development of methods to model and assess extensive risks

The recent UNISDR Global Assessment Report on disaster risk reduction states that the social costs of extensive risks are not accounted for by either governments or businesses and are largely absorbed by low-income countries and communities. This undermines their potential for development and also their prospects of developing resilience to these risks. An analysis of 270,000 records of disaster impact from 56 countries indicated that although extensive disasters only caused 13% of the total deaths they accounted for 43% of the total economic damage. The agricultural sector is one of the most affected by extensive risks. There is a need for the following research:

- How can extensive risk for the most vulnerable communities both in urban and rural areas be effectively assessed and modelled?
- How can these losses from extensive risks be made visible to national governments and policy makers? If these losses are not made visible and their fiscal impact well understood it is difficult for governments to justify increasing expenditure on increasing the resilience of infrastructure
- How can the indirect losses to businesses in low-income countries be measured effectively in order to enable them to be a key advocate for increasing public sector investment?

9.5.8 Distinguishing disastrous events from adverse ones in early warning systems

There is a need to improve early warning systems so that potentially disastrous weather/climate events can be distinguished from “moderately adverse” event. For example, how well can early warning systems discriminate a powerful tropical cyclone (such as typhoon Haiyan that killed approximately 5,000 people in South-East Asia in November 2013), from an “ordinary” severe cyclone. Key research questions include:

- At what lead time can early warning systems reliably distinguish between ”adverse” and “disastrous” events?
- How early warning systems’ abilities to discriminate between events and the lead time at which it can do this be improved?

9.5.9 The effective use of recent developments in Information and Communication Technology (ICT) to improve risk assessments and early warning

The effective use of ICT to improve risk assessments and early warning has been touched upon in many of the above recommendations. The following questions need to be researched:

- How can big data and big data analytics, which are the range of tools and methodologies that use advanced computing techniques to leverage largely passively generated data, (e.g. from the use of mobile phones), and the active collection of observed data by satellites be used effectively to gain insights into the decision-making purposes pre- and post-major disasters in order to improve the response to future emergencies?
- The United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) has started developing smart phone applications and partnering with organisations to develop digital data collection platforms. In recent years there has been a proliferation of open platforms none of which appear to have been widely adopted. There is need to research how open platforms can be made effective. This research needs to be end-user driven.
- Advances in high-performance computing have made the computation of real-time hazards such floods for large spatial areas (e.g. the whole of Africa) a possibility in the near future. Further research is needed as to how what future technological developments are required to make this a reality and how these can be used to allow decision-makers make better inform decisions on appropriate early actions
- There are number of limitations that could prevent advances in ICT have an impact on the most vulnerably with respect to improving their resilience to weather related disasters these include the following constraints that should be investigated:
    - The financial costs in implementing sustainable ICT-based solutions in the three regions
    - There is often a lack of trust in technologies by the intended beneficiaries and other actors in the humanitarian and development communities. These issues need to be explored to enable why this is the case and how relevant technological developments can make a difference to the most vulnerable in society?
    - How the digital literacy of the intended beneficiaries affects the effectiveness of ICT solutions
    - The acceptance of ICT based solution by governments and humanitarian organizations in the three regions
    - Are ICT-based solutions sustainable from a variety of stand points?
    - How can the affected communities get the most benefit from ICT? What are the incentives for different actors to participate in technology-based community solutions?
    - The demographic representation of the communities participating in the ICT-based solutions
    - National societies in Africa and small island states in the Caribbean face challenges in the use of ICT because in these regions ICT skills and education are at a premium and the ICT infrastructure is least developed. There needs to be research to understand how this barrier can be overcome in these regions
    - How can information overload in disaster scenarios be prevented from overtaking the ability of even the most technologically advanced organisations to make sense of it?

9.5.10 Modelling of the health risks posed by weather-related hazards

An important issue in all countries and communities affected by weather-related hazards is their health impacts.

- In the case of floods the flood water can carry and spread pollutants and pathogens whose influence can last for many months after the flood has receded.
- Water scarcity and droughts have knock-on impacts on food security, livelihoods and nutrition.
- Malaria forecasting systems, incorporating seasonal precipitation and temperature forecasts, are in their infancy but have potential to contribute to efforts to reduce transmission.
- Wild-fires and heat-waves and urban heat island impacts may emerge as important weather related hazards, particularly in rapidly growing urban centres and contribute to detrimental impacts on health.

Improvements in knowledge and means of modelling and mitigation of the negative effects of weather-related hazards on health will help to improve the resilience of vulnerable communities.

9.6 Community level research priorities

9.6.1 Contextualising risk and localising early warning information

Arguably the most important barrier to the improvement of risk management and intervention is the limited systematisation enjoyed by vulnerability, development and loss data. This is especially so at the local level and for data disaggregated by gender and other social variables. Without these data the step change in risk management desired by Hyogo Framework for Action (HFA) will be seriously constrained. Researching cost-effective, sustainable and targeted data collection approaches will help breach this impasse. Simply funding national statistical bureaus to collect data is unlikely to succeed. Experiments in user driven or collaboratively managed systems of data collection can build on the experience of La Red and the DesInventar database. These should integrate existing data collection infrastructure (e.g. emergency services call out for example can capture events associated with extensive risk in some cases). This points to research experiments that are co-produced with such communities of practice. Research questions include:

- What institutional and organisational arrangements best support the systematic and sustainable collection of vulnerability, development and loss data?
- How can local communities best be supported with locally specific but rigorously analysed risk monitoring services?
- What kind of loss data are useful for holding early warnings to account, how can this be collected, managed and fed into on-going monitoring and evaluation?

Co-production of research with data users is also important for improving the effectiveness of early warning systems through more effective communication of information. To improve uptake there is a need to make it relevant to the end-users receiving the information. Many stakeholders still utilise indigenous early forecasting methods for natural hazards such as droughts and floods, even when more evidence-based systems are readily available. This is because there is often a high degree of mistrust in science-based warnings when they produce forecasts that are wrong, not locally relevant, in formats that are not easily understandable or via channels that stakeholders do not have access to or trust. There is a need to research participatory approaches in which relevant indigenous and scientific knowledge can be integrated to reduce people's vulnerability to weather-related hazards.

There is a need to address the following questions:

- How can national or sub-national warnings be tailored to local levels (e.g. district, sub-district or community level), and how can this process be managed from a national level?
- How can warning messages contextualise or translate early warning information so that it is meaningful and actionable for community members?
- How should indigenous forecasting methods be integrated with science-based ones?
- There is a need to research the perceptions of the most vulnerable communities and scientists responsible for producing forecasts with regards to the application and reliability of both indigenous knowledge based and conventional forecasting. An evidence base is required with regards to the accuracy of both forms of forecasts.

9.6.2 Effective communication of warnings

In order to improve the effectiveness of communication of early warnings the following are key questions that need to be addressed:

- A review of which communication methods are most effective, including state-of-the-art Information and Communication Technology (ICTs) and localised community led systems for communicating extensive risk. What is the effectiveness of methods using ICT compared to more traditional methods and how can the two be used together to improve the communication of warnings?
- What institutional back-up is required to build in legitimacy (local data production, international oversight)?
- Which dissemination mechanisms effectively reach and lead to consensual risk avoidance amongst those who are most vulnerable to weather-related hazards?
- What are communities' risk perceptions and reactions to probability based forecasts and warnings?
- How can probabilistic forecasts and uncertainty be communicated effectively to a range of different stakeholders?

The use of probabilities and uncertainty does not have to be a reason for inaction. Two-way exchanges of information between end-users and forecasters can mitigate misunderstandings and help to improve the effectiveness of warnings. There is a need to research how this can be achieved effectively.

In the past decade the penetration of mobile phones in low-income countries has grown exponentially. A low-cost, scalable and accessible mobile information architecture has led to new and emerging technologies to address challenges in disaster risk reduction. For example, a recent report on the African telecommunications market reported that mobile phone penetration in Africa hit 80% in the first quarter of 2013 and is still growing at 4.2% annually (Elnadi, 2013). The same pattern is emerging in South Asia where there are 73.8 mobile phones per 100 of the population in Bangladesh (a similar level to that which exists in Canada) (BTRC, 2013). The use of mobile phones in communicating messages and also analysing how people behave during emergencies in order to assess the risk as an event unfolds and to provide assistance where it is most required.

Modern media technology offers a wide array of tools and opportunities. These should be taken advantage to reduce the impacts of weather-related disasters. Individually, any of these tools can be effective at reaching people with information, but it is when they are effectively combined together, and integrated with the work of emergency responders, that their power can really grow. More research is needed to further establish the direct impact of beneficiary communications on the health and wellbeing of communities and the overall effectiveness of operational programmes.

9.6.3 Sustainability of effective early warning systems between major events

The main factors that affect the sustainability of early warning systems include:

- The quality of the information being communicated
- Effective governance and institutional arrangements
- A multi-hazard approach (including cascading hazards) to early warning
- The involvement of local communities
- A consideration of gender perspective and cultural diversity
- Financing

Many successful early warning systems (e.g. the cyclone early warning system in Bangladesh) are reliant on volunteers. There is a need to investigate how this model can be transferred to other countries in other regions. Other areas that need to be explored include:

- Demonstrate the cost savings and/or livelihood improvements to justify governmental, donor and user contributions to the costs
- How can the sustainability of volunteer based early warning systems be evaluated?
- What are the best ways to broaden single hazard early warning systems into multi-hazard early warning systems?
- How can early warning systems be used disseminate other types of information (e.g. such as livelihood-related information) during periods of low-risk, and how can this best be done this whilst ensuring the system's effectiveness is maintained and that early warning for the original hazard is not negatively impacted?
- In many countries short-term and unpredictable financing is a challenge to the sustainability of early warning systems. How can early warning systems be made to be financial sustainable in low-income countries where resources are often limited?
- In some countries there are multiple sources of warning messages from different agencies. How can these sometimes conflicting messages be avoided to ensure that there is clarity in warnings and to avoid potential inertia in the response to forecast hazards? Are consensus forecasts (e.g. forecasts produced by Regional Climate Outlook Forums) useful and effective for different stakeholders?

9.6.4 Scaling-up successful community-level early warning systems and risk assessments

While Kenya has successfully scaled-up a small, community-level drought early warning system into a statutory institution with high political leadership attached to the process, in many low-income countries there are many successful community based early warning systems and risk assessments that have not be successfully scaled up to either a regional or national scale. Research is needed to support countries in the development of frameworks to successfully scale up community based initiatives. Methods to achieve this could include:

- Research to identify the key barriers to scaling up successful risk assessments and early warning systems in low income countries through interviews and also liaising with experts in large-scale implementation in the health sector who have led successful national or global health scale-up campaigns.
- How incentives can be built in at a community level to make them sustainable, replicable and sustainable in different sub-regions of the same country?

Research from the medical field in low income countries has shown that scaling up a successful intervention is not an isolated process. Its failure or success is closely tied with a complex array of contextual factors, such as political will, politics, the regulatory environment, the donor environment (including whether donors coordinate their efforts or act in isolation), and the fiscal environment. In the health sector these can operate at multiple levels of the health system. For example, the research literature suggests that financial constraints to scale-up act at the individual, household, community. The same issues need to be researched for community based risk assessments and warning systems.

SECTION 10

Conclusions

The objective of the Science for Humanitarian Emergencies and Resilience (SHEAR) research programme will be to bring forward the next generation of more systematic, transparent and comprehensive risk information and early warning systems for humanitarian and development purposes.

Three underpinning principles/and cross-cutting themes will be:

- “End-to-end” research i.e. from science to integration into decision making.
- Open, transparent data and models
- Supporting local capacity development

The scoping study findings show that:

(i) There has been some progress on improving national and local risk assessments and in early warning as part of the Hyogo Framework for Action (HFA) but this is highly variable across Africa, the Caribbean and South Asia; our own assessment and other independent surveys show that a lot more work is required to produce robust, reliable and accessible information to reduce vulnerability and manage risks.

(ii) There are a range of barriers preventing the development of effective risk assessments and early warning systems. These were universal across Africa, the Caribbean and South Asia and included ineffective communication of warnings, lack of capacity and funding, ineffective coordination, poor data management and limited data access and a lack of monitoring and evaluation of early warning systems.

(iii) There is a requirement for multi-disciplinary research with a strong focus on understanding aspects of adaptive capacity and vulnerability, effective risk communication and community level actions as well some well-focused improvements in technical and underpinning scientific aspects of early warning systems. This includes specific research needs on scaling up of local risk assessments and community early warning systems. .

This scoping study has concluded that in terms of weather-related hazards the research priorities for the three regions considered are as follows, although there is a strong case for considering multiple hazards and including other weather-related risks in future research studies:

- Africa: Droughts and floods
- The Caribbean Floods and droughts
- South Asia Droughts and landslides

Table 7 provides an overview of the research priorities detailed in this report and their potential impacts. The research gaps have been arrived at via engagement with stakeholders in the three regions via interviews, survey and workshops. Further background is provided in the standalone Annexes 1, 2, 3, 4, 5 and 6.

Research goals	Example research questions (for additional research questions and detailed discussion see Section 9)	Potential research impacts
National level		
Insight to overcome governance and management challenges	• How to institutionalise and hand over successful community pilots to government? • In circumstances of poor governance, lack of political support or conditions of conflict, what early warning systems and risk assessment techniques are the most effective, and what actions can be led at the community level? • What can be done to improve trans-boundary and transnational collaborations and information sharing? This is especially the case for large river basins (e.g. the Zambezi, Ganges).	• An understanding how institutional factors influence risk assessment and the effectiveness of early warning systems • Recommendations for capacity building • Improving the links between early warnings and early actions • Providing guidance on effective risk assessments and early warning systems for conflict situations • Improved trans-boundary cooperation with respect to early warning systems
Better monitoring and evaluation of early warnings and risk assessments	• How can we better monitor the outcomes of each step in the risk management cycle and interactions between phases to improve performance? • How can risk monitoring, analysis and early warning be tailored to the needs of different user groups, from national financial managers to economic sectors, social sector actors and individual farmers at risk or local government?	• Improved understanding of effectiveness, what works and what does not work • A method to provide accountability that will enable improvements to be made • Protocols, monitoring and evaluation frameworks, learning • Improvements to systems, increasing effectiveness and reducing loss of life
Understanding of issues related to people with disabilities and the most vulnerable in society	• How can the factors relating to the most vulnerable in society (people with disabilities, the socio-economically disadvantaged) be included in disaster management policy and governance mechanisms in low-income countries? • How can the needs of the most vulnerable in society be addressed in early warning and risk reduction for weather-related hazards? •	• Recognition of this issue in policy and governance mechanisms, as well as emergency plans for a range of hazards.
Funding mechanisms	• What can be done to ensure that funding mechanisms for risk assessments and early warning systems are targeted so that the funding is most effective and is also sustainable?	• Improvements in the sustainability of risk assessments and early warning systems
Data, information and methods		
Methods for effective use of low-cost sources of information (e.g. 'crowd	• How useful is the information that is generated by crowdsourcing for risk assessment and early warning systems?	• Improved access of a range stakeholders to information on risk as well as early warnings of weather-related hazards

Research goals	Example research questions (for additional research questions and detailed discussion see Section 9)	Potential research impacts

sourced' data using mobile phones) on hazard, vulnerability, exposure and loss	• How can the data generated be used by national and locally based government organisations?
	• How can the use of low-cost sources of data and information need be sustained in the long term to manage issues such as:
	  • Data duplication
	  • Data fragmentation (e.g. multidisciplinary analysis requires data from across specializations; however, these data are often segmented into 'silos
	  • Data access and availability
		• Innovation and the use of risk and early warning products
		• Improved collection of disaggregated vulnerability data and its assessment
		• Improved collection of disaggregated damage and loss data and its assessment
		• Integration of disaster risk reduction and development from disaggregated data collection to policy integration
		• Development of protocols to deliver sustainable, low cost data sets on vulnerability, exposure and loss for vulnerable communities and key assets (e.g. water supply and sanitation, health and education infrastructure)

Improvements in climate modelling	• In many parts of Africa (e.g. the Sahara desert) there are large areas where there is a dearth of climate monitoring stations. Would setting up stations in these areas improve the accuracy of drought forecasting and also help to assess the risks posed by climate change? • How can improvements be made in the prediction of the variability of ocean temperatures and teleconnections • How can the representation of convective processes for Africa be improved? • How can the downscaling of numerical weather models be improved to provide stakeholders with more useful localised forecasts, including real-time predictions? • Current seasonal forecasts for droughts do not provide users of the information with a distribution of rainfall throughout the rainy season. What research is required to improve intra-seasonal predictability?	• Improved monitoring to support local risk assessments and improved climate models • Increased skill that results earlier warnings that have a greater degree of confidence • Improvements in downscaling that provide beneficiaries such as farmers with information that is more useful to them (e.g. the distribution of rainfall throughout the growing season)
Improved flood risk assessment, early warning of floods and long-term forecasts of river flows	• How can the accurate elevation data, extreme rainfall estimates, flood flows, extreme sea level and information on defences and vulnerable communities be rapidly assimilated in data sparse regions? • How can proxy data, such as historical flood extents and local knowledge be used to build up a better picture of flood	• Regional flood hazard and flood risk maps • Improved estimates of flood risk and assessments of loss and damage • Recognition of how short and medium scale forecasting could improve emergency planning. • Development of information products and processes

Research goals	Example research questions (for additional research questions and detailed discussion see Section 9)	Potential research impacts
	risk? What roles can global scale modelling (Pappenberger et al., 2013) and remote sensing play in improved flood warning systems? (See below). • How can flood forecasting and early warning systems make use of medium-ranged forecasts (i.e. lead times between five and 15 days)? How could this information be used by decision makers? • Can the integration of hydraulic models and behavioural agent-based models be used to evaluate emergency management interventions such as the location of cyclone shelters, the timing of warnings, and the management of evacuation routes? • How can the accuracy of long-term (e.g. six month in advance) forecasts of river flows be improved?	for dissemination. • Use of medium term and seasonal forecasts for planning humanitarian responses, e.g. ensuring timely mobilisation. • Improvements in the prediction of water availability with respect to agricultural production, hydropower and other sectors
Distinguishing between “adverse” and “disastrous” events	• How can the lead times to distinguish between adverse and disastrous events be increased and the accuracy of this distinction be improved?	• Improvements in early response for cyclones and slow onset disasters such as droughts
Use of remote sensing data in improving early warning systems and real-time risk assessments	• How can new remote sensing techniques be used to monitor weather-related hazards and support relevant hazard, vulnerability and risk models? • Do new satellite sensors offer improved information products that can be integrated into risk assessments and early warning systems? • How can sufficient and cost-effective ground-truth information be collected against which remote sensing algorithms can be validated and further improved?	• Improved awareness and capacity for using remotely sensed products in risk assessments and early warning systems. • Design of new data products that incorporate ground based observations and remotely sensed data. • Guidance on designing ground observation monitoring systems.
Modelling of the risks from multi-hazards	• What are the best methods of multi-hazard risk assessments that are particularly focused on the most vulnerable? How can these be scaled up to a sub-national and national scale so that they can be used by policy makers? • What are the ‘cross-hazard’ dependencies and interactions among hazards, exposure, vulnerability, and multi-hazard risk management at national and sub-national scales?	• Improved understanding of systemic risks. • Improved estimation of damages and loss, cumulative impacts.
Integrating early warning systems with risk	• What are the best ways to integrate early warning systems with risk assessments (in terms of people’s livelihoods)?	• Provision of real-time forecast of how weather-related hazards will impact on people’s livelihoods

Research goals	Example research questions (for additional research questions and detailed discussion see Section 9)	Potential research impacts
assessment (including extensive risks)	• How do the most vulnerable groups cope with weather-related hazards?	• Account taken of cascading hazards in risk assessments, including vulnerability analysis
Management of extensive risk	• How can extensive risk for the most vulnerable communities both in urban and rural areas be effectively assessed and modelled? • How can these losses from extensive risks be made visible to national governments and policy makers? If these losses are not made visible and their fiscal impact well understood it is difficult for governments to justify increasing expenditure on increasing the resilience of infrastructure • How can the indirect losses to businesses in low-income countries be measured effectively in order to enable them to be a key advocate for increasing public sector investment?	• Provision of evidence-based estimates of extensive risk, including suitable vulnerability analysis, for a range of hazards for urban and rural areas • Provision of direct and indirect, disaggregated losses that result from extensive risk especially for areas of informal housing in urban contexts • Consideration of the role for early warning in places exposed to frequent, creeping or extensive risk.
Effective use of recent developments in Information and Communication Technology (ICT)	• How can ‘big data’ and ‘big data analytics’ be used effectively to gain insights into the decision-making purposes pre- and post-major disasters in order to improve the response to future emergencies? • Do advances in high-performance computing make computation of real-time hazards such floods for large spatial areas (e.g. the whole of Africa) a possibility in the near future?	• Provision of information that will allow an improved response to future disasters • Development of sustainable open platforms that are end-user driven • Development of real-time, continental scale hazard and risk maps for certain weather-related hazards • Development of how trust in ICT solutions can be improved with certain humanitarian actors and vulnerable communities • Increased capacity, especially in Africa and the Caribbean, to implement sustainable ICT-based solutions
Modelling of the health risks posed by weather-related hazards	• What are the secondary impacts of flooding on health and how can these risks is managed? • What role could global and national malaria forecasting systems, play in tacking malaria prevention? • How significant are heat-waves and urban heat island hazards in rapidly growing urban areas and do these have detrimental impacts on health?	• Acknowledgement of risks in health plans • Uptake of medium term and seasonal forecasts for planning humanitarian responses, e.g. ensuring timely mobilisation.
Community level		
Contextualising and localising risk and early	• What institutional and organisational arrangements best support the systematic and sustainable collection of	• Co-production of risk assessments and early warning systems with local stakeholders and responsible

Research goals	Example research questions (for additional research questions and detailed discussion see Section 9)	Potential research impacts
warning information	vulnerability, development and loss data? • What kind of loss data is useful for holding early warning to account, how can this be collected, managed and fed into ongoing monitoring and evaluation? • How can national or sub-national warnings be tailored to local levels (e.g. district, sub-district or community level), and how can this process be managed from a national level? • How can warning messages contextualise or translate early warning information so that it is meaningful and actionable for community members? • Should indigenous forecasting methods be integrated with science-based ones? If so how can this be done?	agencies. • Contextualisation of warning messages so that they are relevant to the livelihoods of the beneficiaries • An evidence-base for the use of scientific and indigenous forecasting methods
Effective communication of warnings	• Which communication methods are most effective, including state-of-the-art Information and Communication Technology (ICTs) and localised community led systems for communicating extensive risk? • Which dissemination mechanisms effectively reach and lead to consensual risk avoidance amongst those who are most vulnerable to weather-related hazards? • What are communities' risk perceptions and reactions to probability based forecasts and warnings? • How can probabilistic forecasts be communicated effectively to a range of different stakeholders?	• Improvements in response as a result of more effective communication • Use of probabilistic warnings to improve lead times for certain groups of stakeholders
Sustainability of effective early warning systems between major events	• How can the sustainability of volunteer based early warning systems be evaluated? • What are the best ways to broaden single hazard early warning systems into multi-hazard early warning systems? • How can early warning systems be made to be financial sustainable in low-income countries where resources are often limited? • How can conflicting messages be avoided to ensure that there is clarity in warnings and to avoid potential inertia in the response to forecast hazards? Are consensus forecasts (e.g. forecasts produced by Regional Climate Outlook Forums) useful and effective for different stakeholders?	• Protocols that allow successful volunteer based early warning dissemination to be "transplanted" to other countries and regions • Improvements in the sustainability of early warning systems • Use of early warning systems to disseminate other information that is useful for beneficiaries (e.g. health information)

Research goals	Example research questions (for additional research questions and detailed discussion see Section 9)	Potential research impacts
Scaling-up successful community-level early warning systems and risk assessments	• What are the key barriers to scaling up successful risk assessments and early warning systems in low income countries? • What lessons can be learnt by liaising with experts in large-scale implementation in the health sector who have led successful national or global health scale-up campaigns? • How can incentives be built in at a community level to make early warning systems sustainable, replicable and sustainable in different sub-regions of the same country?	• Frameworks that allow successful community-based initiatives to be scaled up to a sub-national and national scale

Table 7 An overview of the research priorities and their potential

SECTION 11

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SECTION 12

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