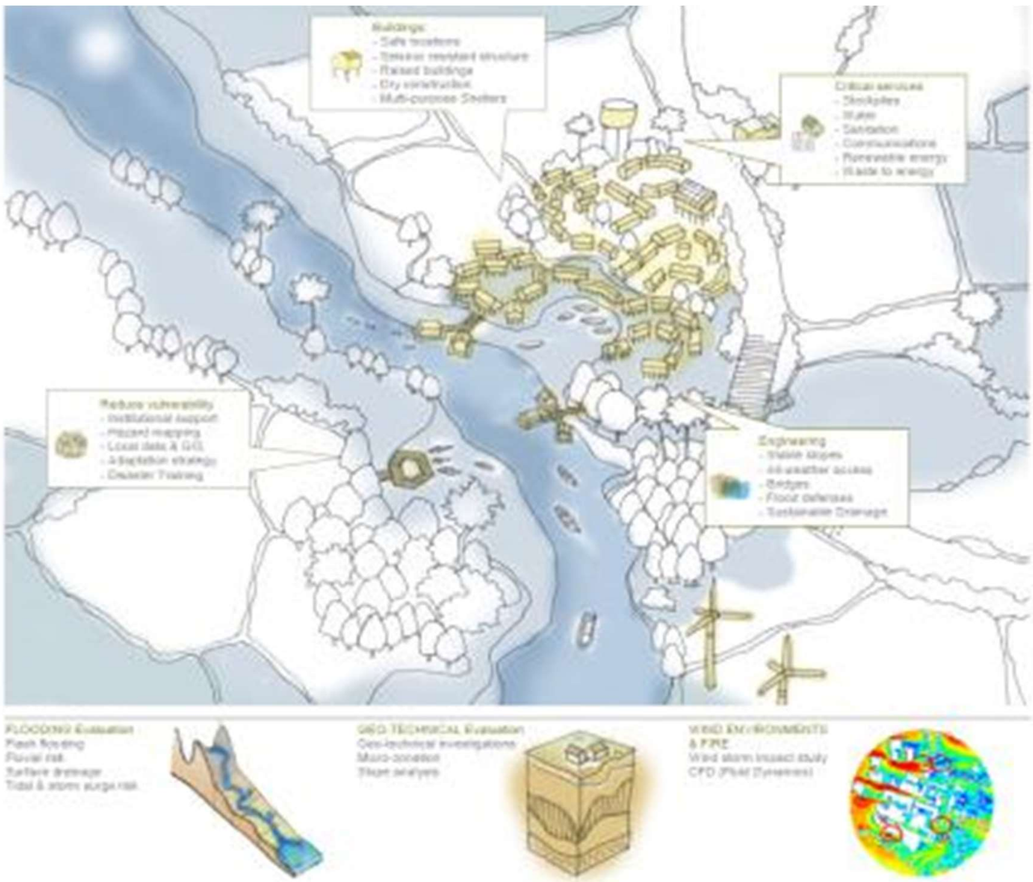


Insurance Instruments for Africa

Climate Adaptation – First Phase

Final Report

April 2013[1]

Nordic Development Fund

[1] Hydro-meteorological data updated by Met Office, 2018

Contents

List of appendices

Glossary

'Vulnerability' and related exposure

Vulnerability as defined by the World Bank is *'the condition of being at risk of any potentially harmful event'* (Cafiero & Vakis, 2006. p.4). In the context of this report, vulnerability therefore includes any risk arising from changes in climate compared with the regional average. Vulnerability within this context, can often lead to populations facing exposure to the following:

- Financial hardship
- Unemployment
- Detrimental impacts on health
- Decrease in social capital (education, social standing) Other social, physical and cultural loses.

The UN–ISDR defines vulnerability as 'the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of a hazard'.

The Climate Vulnerability Monitor 2012 expands on the factors which have been found to influence vulnerability to include: income levels, access to information, education, social safety nets, degree of corruption, access to global markets, vegetation, topography and natural resource supplies. A paper by Brooks et al (1994) identifies over 20 factors within these categories which influence vulnerability. Literature on climate vulnerability indicates a range of methodologies but the formula that is commonly applied and which we would propose for this work is the risk triangle: Natural Hazard x Vulnerability x Exposure = Risk

Exposure

'People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses' (UNISDR, 2010)

Exposure refers to the quantity of the exposed elements: 'Elements at risk, an inventory of those people or artefacts that are exposed to a hazard' (UNDP, 2004). One may add environmental/natural assets to the list of potentially exposed items, although these are more difficult or often impossible to quantify.

Hazard

For the purposes of this paper, we will be using the United Nations Office for Disaster Risk Reduction (UNISDR) definition of risk, which is as follows:

'A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.' (UNISDR, 2007)

For this project we have limited 'hazards' to natural hazards and we have further narrowed this down to assess floods, droughts and storms. The frequency of these events between 1950 and 2011 can be seen in figures 1, 2 and 3. However, it should be noted that the frequency and severity of these events is likely to increase with time (IPCC SREX 2012) and that the past is not necessarily a good predictor of the future.

Insurance

Insurance can be defined as:

'A contract whereby an insurer promises to pay the insured a sum of money or some other benefit upon the happening of one or more uncertain events in exchange for the payment of a premium. There must be uncertainty as to whether the relevant event(s) may happen at all or, if they will occur (e.g. death) as to their timing.' (Lloyds of London, 2012)

Climate Change

Climate change, for the purpose of this paper can be defined as the following:

'…a change in the state of the climate that can be identified… by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use' (International Panel on Climate Change, 2001)

Adaptation

'The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.' (UNISDR, 2009)

Risk

Is the measure of potential loss which is commonly expressed as an index for insurance purposes. Technically, the introduction of insurance instruments would increase the 'adaptive capacity', therefore lowering vulnerability and potentially reduce risk.

National Meteorology and Hydrology Services (NMHS)

Meteorological and hydrological functions are often fulfilled within the same institution, known as Meteorological and Hydrological Services but there are sometimes separate meteorological and hydrological services within a country. The general acronym NMHS is used to capture these.

Hydro-met Data

Hydro-Meteorological data refers to data collected on hydrology (e.g. river flow) and meteorology (e.g. precipitation, temperature, wind speed and direction, radiation)

Climatological Records

Climatological records refer to records of past meteorological data which are usually collected by an NMHS.

Numerical Weather Prediction

The use of mathematical models to represent the atmosphere and oceans in order to forecast the weather

List of Acronyms

ACCRA	Africa Climate Change Resilience Alliance (ACCRA)
ACP	African Caribbean and Pacific group countries
ACGFS	Agriculture Credit Guarantee Scheme
AEJ	African Easterly Jet
AES	Agriculture and Environmental Services
AFR	Africa Risk View

AFTFP	Africa Finance & Private Sector Development Department
AMMA	African Monsoon Multidisciplinary Analysis
ART	Alternative Risk Transfer
ASEAN	Association of Southeast Asian Nations
AU	African Union
AWS	Automatic Weather Stations
CCA	Climate Change Adaptation
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CIF	Climate Investment Fund
CIMA	Inter-African Conference on Insurance Markets
CCKP	World Bank's Climate Change Knowledge Portal
CNAAS	Compagnie Nationale d'Assurance Agricole du Senegal
CRED	Centre for Research on the Epidemiology of Disasters
CSRP	Climate Science Research Partnership
DFID	Department for International Development
DHAN	Development of Humane Action
DRM	Disaster Risk Management
DRF	Disaster Risk Financing
DRFI	Disaster Risk Financing and Insurance
DRR	Disaster Risk Reduction
ECMWF:	European Centre for Medium Range Weather Forecasts
EEPCO:	Ethiopian Electric Power Corporation
EM DAT	Emergency Events Database
EP	Exceedance Probability Curve
EPSAT-SG	Estimation of Precipitation by Satellite Second Generation
FCFA	Future Climate for Africa
FISCR	Financial Innovations for Social and Climate Resilience

GAR	Global Assessment Reports
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
GHCN-D	Global Historical Climatology Network - Daily
GHCN	Global Historical Climatology Network
GIF	Global Index Insurance Facility
GPCP	Global Precipitation Climatology Project
GPCP GPI	Global Precipitation Climatology Project Global Precipitation Index
GTS	Global Telecommunications System
HARITA	Horn of Africa Risk Transfer for Adaptation
HDI	Human Development Index
HEP	Hydro Electric Power
HFA	Hyogo Framework of Action
IBRD	International Bank for Reconstruction and Development
IBTrACS	International Best Track Archive for Climate Stewardship
ICAO	International Civil Aviation Organisation
ITCZ	Inter Tropical Convergence Zone
IDA	International Development Association
IPCC	International Panel on Climate Change
IFC	International Finance Corporation
ILO	International Labour Organisation
ILRI	International Livestock Research Institute
IFPRI	International Food Policy Research Institute
KENGEN	Kenya Electricity Generating Company
KMD	Kenya Meteorological Department
LAC	Local Adaptive Capacity

MCI	Multi-Peril Crop Insurance
MCII	Munich Climate Insurance Initiative
MetDB	Met Office Database
MFIs	Microfinance Institutions
MIDP	Microinsurance Development Program
MO	Meteorological Office
MSME	Micro, Small and Medium Enterprises
NAPA	National Action Plan for Adaptation
NCDC	National Climate Data Centre
NCMS	National Collateral Management Services Limited
NDVI	Normalised Dry Vegetation Index
NGOs	Non-Governmental Organisations
NHIS	National Health Insurance Scheme
NIAF	Nigeria Infrastructure Advisory Facility
NIMET	Nigeria Meteorological Agency
NMA	National Meteorological Agency
NM(H)S	National Meteorological Hydrological Services
NMS	National Meteorology Services
NOAA	US National Oceanic and Atmospheric Administration
NPCI	Named Peril Crop Insurance
NWP	Numerical Weather Prediction
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
ODA	Official Development Assistance
ODI	Overseas Development Institute
OFDA	Office of Foreign Disaster Assistance
PIDG	Private Infrastructure Development Group
PPP	Public Private Partnerships

PSNP	Productive Safety Net Programme
SEEC CRIF	South Eastern Europe and the Caucasus Catastrophe Risk Insurance Facility
SSA	Sub-Saharan Africa
TAMSAT	Tropical Applications of Meteorology using Satellite Data
TCIP	Turkish Catastrophe Insurance Pool
TEJ	Tropical Easterly Jet
TRMM	Tropical Rainfall Measuring Mission
UKMO	UK Meteorological Office
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UN-FCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
WB	World Bank
WCIDS	Weather and Climate Information and Decision Support Systems
WFP	World Food Programme
WMO	World Meteorological Organisation
WRMS	Weather Risk Management Service
WUA	Water User Associations

Foreword

In 2013, the World Bank commissioned a consortium led by IMC Worldwide, supported by CaribRM & the Met Office, to develop a report titled **Insurance Instruments for Africa Climate Adaptation – First Phase**. The context of the original 2013 report was to demonstrate that risk transfer instruments, including insurance, were increasingly relevant in improving the resilience of sovereign states and communities to weather and climate impacts on lives, vital assets and investments. Adaptation techniques across relevant sectors are therefore required In order to create a robust risk transfer system able to mitigate these impacts. Innovative approaches for the development of instruments and methodologies, which are fit-for-purpose and affordable are called for.

The 2013 report objective was to assess the potential of developing suitable insurance and insurance-like markets within Sub-Saharan Africa (SSA). The contributors' initially shortlisted countries that were highly vulnerable to floods, droughts and storms and then assessed the accessible insurance instruments available to them. It was concluded that whilst some of these countries already had an established insurance market others required to create certain conditions, which would enable them to develop this market further.

Whilst the report was completed and submitted as a final draft however, it was never formally launched. Through parallel initiatives at the Nordic Development Fund and the World Bank, looking specifically at finance instruments available to the hydropower sector, this report has been revisited. The Met Office was asked to review the areas of the report, which specifically relate to weather & climate risk and have therefore, provided detailed updates to sections 4 and 5, with associated appendices.

In addition, NDF (the Nordic Development Fund), the World Bank, GIZ (the Deutsche Gesellschaft für Internationale Zusammenarbeit) and IHA (International Hydropower Association) conducted a workshop titled ''Assessing and Mitigating the Hydrologic Risk in hydrology-dominated energy systems (focus on Africa)'' in a closed session held in the UK 30th November – 1st December 2017. To ensure the updated 2018 revised report reflected the advances in the sector and captured climate data requirements to mitigate hydrologic risk, Met Office were also asked to contribute in order to ensure the Hydromet updates to the report were aligned with some of the advances discussed.

The workshop was well attended and participated in by thirty-five individuals, representing 17 countries. The participants represented private and public sectors, ministries, and universities along with leading institutions in the hydropower field. The IHA co-hosted the workshop due to its desire to advance sustainable hydropower. The World Bank expressed interest in moving beyond mitigation, hydrologic triggers and economic tools.

Designed as a share and focus opportunity, participants shared the latest in academic approaches to modelling hydrologic risk and mitigation or insurance options. The closed workshop provided the space for all to detail successes and challenges in this context. There was also a focus on Africa and the participants' experiences of commissioning and operating hydropower facilities, and dealing with climate and risk mitigation.

Presentations provided by academia and the private sector displayed their respective approaches to combining publicly available datasets with private expertise/technical advances to provide approaches in data sparse areas. These techniques have been tested and validated, and are now considered to be of sufficient skill to estimate energy resources. In some instances, these techniques can give sufficient evidence to leading insurers to provide risk exposure cover.

Operators of successful hydrologic facilities in Uruguay, USA, China and Brazil provided detail of their approaches to risk mitigation and management. They evidenced how they have secured the appropriate level of financing to overcome the challenges of excess or deficient water availability. A world-leading insurer presented on the types of premium that they can offer, how they assess the risk primarily through observed rainfall data and, should they lack access to observations how they explore different options of cover. Alternative financing mechanisms were explored, such as climate bonds, and the role of the development banks in this sector.

Then the focus turned to the needs and reality of operating similar facilities in Africa. Met Office and ACPC (the Africa Climate Policy Centre) provided two presentations, on the availability of, and gaps in, data coverage and the support currently provided to the NMHS in Africa. It also introduced the African Risk Capacity (ARC) http://www.africanriskcapacity.org/ one initiative, which has proved successful in Africa – funded by DFID and now adopted by the African Union.

It was posited that to ensure a risk is fully managed, there needs to be forecast or model flows across all timescales, i.e. hourly to climate change using multi-model simulations. In reality, in many locations the quality and reliability of data is lacking. Questions were raised as to, 1) how do you manage the desires of the developer compared to government. 2) How do you share risk when your facility or source of water is transboundary?' And 3) how do you manage short term excesses of water and/or inter-annual or decadal trends of low water availability? In answer to question 1, all agreed that unfortunately not much progress had been made on integrating the advances of private sector into the public sector and, specifically there had been very little focus on Africa over the past 5 years. Concerning question 2 it was agreed that whilst some good examples of transboundary risk sharing exist, namely Laos PDR across to Thailand, the agreement used to facilitate cross border agreement could be prohibitive in some scenarios, where competing political or social factors are prevalent. For question 3) multiple small storage facilities with appropriate financial instruments appeared a better option than the traditional option of creating a large storage facility, which would in turn require significant financing and political backing.

Whilst the participants agreed the challenges remained broadly the same from 2013, it was clear that there were some differences in approach being developed where there is access to derived or observed time series of data to assess current and future risk and to monitor performance.

Unfortunately, these advances are not as widely known about or used in Africa. Representatives from Ghana, Senegal & Cameroon all presented their successes and challenges in managing hydrologic risk and their contributions highlighted that the advances in financing progressed elsewhere in the world are not necessarily exported to Africa, where access to data and particularly quality data is limited. These limitations are currently being addressed through large Hydromet and financing investment programmes funded by World Bank, Nordic Development Fund, DFID and other development agencies, however it is a long modernisation process, which will not provide immediate improvements in data availability.

<u>Conclusions</u>

Overall, participants agreed on the following statements:

- There is need for capacity building, modelling, climate resilience guidelines applicability, increasing awareness about risk.
- Hydrological risk mitigation covers multiple disciplines; focus on what is achievable is key.

- Replicate examples to achieve an integrated approach to water management
- Interconnections will have a prominent role in hydrologic risk mitigation and alternative financial instruments.
- Risk will exist even with the combination of the parametric systems.
- There is a need to understand the weaknesses of the models.
- There is an opportunity to optimise the use of hydropower, not just financial instruments. Hydropower is going to be the cheapest source of energy compared solar and wind. Opportunities to combine contracts for different timescales and combined renewable energy sources.
- And, as ever, the need for more regular opportunities for sector groups to meet to informally and in confidence to compare innovative ideas and find a way forward.

Next Steps:

This updated 2018 report will be used to raise awareness of the challenges faced in the design and delivery of robust risk mitigation plans for Hydropower and the potential consequences to social and economic mobility of nations. It will also highlight where future research can develop the optimum modelling techniques.

This need is demonstrated wider through the establishment of the World Bank and WMO of the Global Weather Enterprise[2] initiative and DFID establishing the Centre for Global Disaster Protection[3]

It is hoped the findings in this 2018 updated report are a useful baseline for understanding the challenges faced in the Hydrologic Risk arena. The report has primarily captured updates in the Hydromet over the past 5 years but the owners welcome any further information you have, which might complete any knowledge gaps.

[2] https://public.wmo.int/en/resources/bulletin/weather-enterprise-global-public-private-partnership
[3] https://www.odi.org/comment/10531-looking-beyond-insurance-uk-s-new-disaster-protection-centre

EXECUTIVE SUMMARY

Keywords: Sub-Saharan Africa (SSA); insurance markets development; client requirements; client value; co-benefits of insurance markets; insurance-adaptation interface; coping mechanisms; high weather risk countries; weather data; insurance instruments mapping; operational conditions; insurance provider requirements.

Risk transfer is increasingly relevant for improving the resilience of sovereigns and communities in dealing with weather risk to vital assets and investments. This requires innovation and development of instruments that are fit-for-purpose and affordable. Within this context, the World Bank has commissioned the '*Insurance instruments for Africa Climate Adaptation*'[4], (amongst a cluster of other related projects), to assess the potential for enabling the development of suitable insurance and insurance-like markets within SSA. In the first instance, these will be applied in countries that the project has shortlisted as highly vulnerable to floods, droughts and storms. Some of these countries already have established insurance markets whilst others may need help to develop them further.

Insurance: What to expect?

Established insurance markets rely on insurance products that are either mandatory and/or highly relevant from the client perspective. Potentially, the types of investments and assets that could benefit from insurance are numerous; however, for this study the general categories of insurance looked at, are agriculture, sovereign, property/catastrophe and microinsurance (being the latest addition). It is important to approach the potential of insurance in SSA with an open mind, as there are many assets and investments that are at risk from weather events for which innovative products could be developed.

Insurance is not the only tool to manage weather risk; in addition to risk reduction, financial losses can also be compensated through savings or contingency borrowing to avoid, for instance, a decline in living standards or the failure of a service (e.g. staff payments). Insurance is thus most relevant when other options are ruled out as inadequate to compensate for the level of losses, or when it is the most cost-beneficial option.

Recent experience suggests that insurance may be useful where many of the following conditions are met:

- Socio-economic losses are well above what savings or contingency funds can cover;
- The extreme weather events causing the losses are highly improbable;
- The capacity to adapt to extreme weather is low or growing at a slow pace.

Understanding *client requirements* and generating *client value* is a key lesson that has emerged from existing experience in seeding new insurance markets. As previously mentioned, unless insurance is mandatory it needs to be relevant to the clients. Client value is defined from the client's perspective rather than the seller's perspective. Often insurance providers sell products which have little relevance to the client or are far too demanding for the context, thus they fail to take a foothold in the market.

[4] The 'Insurance Instruments for Africa Climate Adaptation' is currently in the first of two phases[1] in supporting African nations in finding **innovative approaches to building resilience to historical climate vulnerability and climate change.** Phase 1: *Identification of priority country clusters in sub-Saharan Africa (SSA)* and Phase 2 is '*In-depth Analysis of the Potential Feasibility of Climate Insurance Programs of Specific Hazards and Country Clusters'*.

Insurance instruments can significantly assist SSA countries to increase their resilience and reduce the impacts and overall costs of natural disasters. However, insurance mechanisms in the region have not been widely developed. This is because of several factors including: poor understanding of client requirement; low penetration of insurance; lack of dissemination and diffusion; poor contribution from the private sector; a high dependence on donor support; and lack of dedicated funding mechanisms.

Weather risk in SSA

Floods, droughts and storms have been identified as key weather risks that undermine economic progress in Sub-Saharan Africa (SSA). In addition, the increasing volatility of weather patterns resulting from climate change is expected to pose further challenges to the region's development and undermine the benefits from investment in the region. SSA is a fast-growing region and it is safe to say that assets and investments in multiple sectors are at risk.

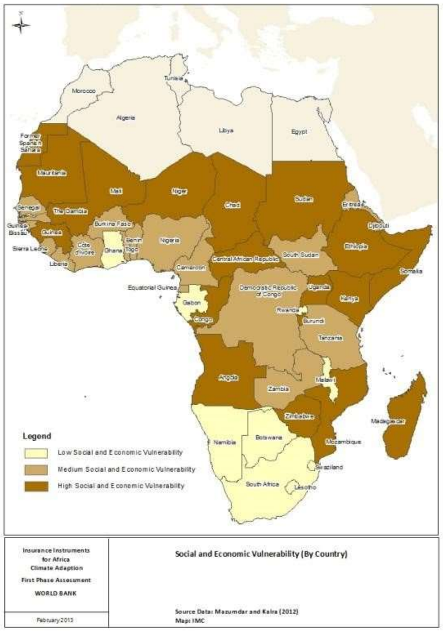
This report is based on desk-based research into weather risk and relevant insurance instruments within the region. For the purpose of this study, weather risk from floods, droughts and storms has been prioritised for SSA countries. Existing insurance markets in Africa have been researched and categorised as sovereign disaster risk transfer, agricultural insurance, property catastrophe risk insurance and disaster microinsurance.

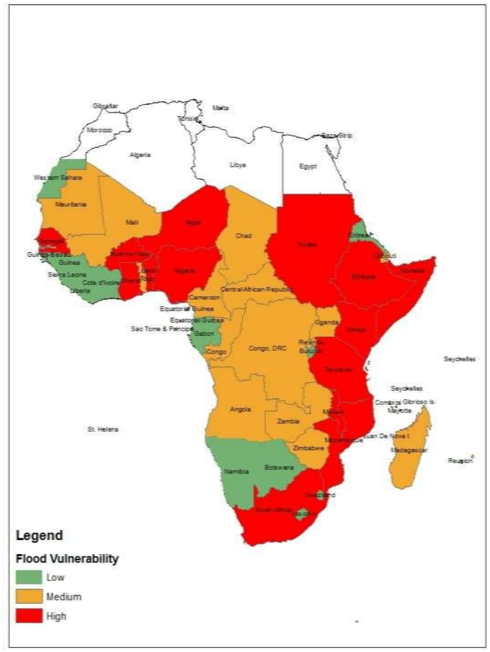
Assessment of whether a country may benefit from climate risk financing has involved mapping occurrences of cyclones, floods and droughts, and assessing a county's vulnerability to these; while assessing a country's readiness to set up insurance markets has considered the availability of suitable hydro-meteorological data amongst a host of other local factors (described in the main text).

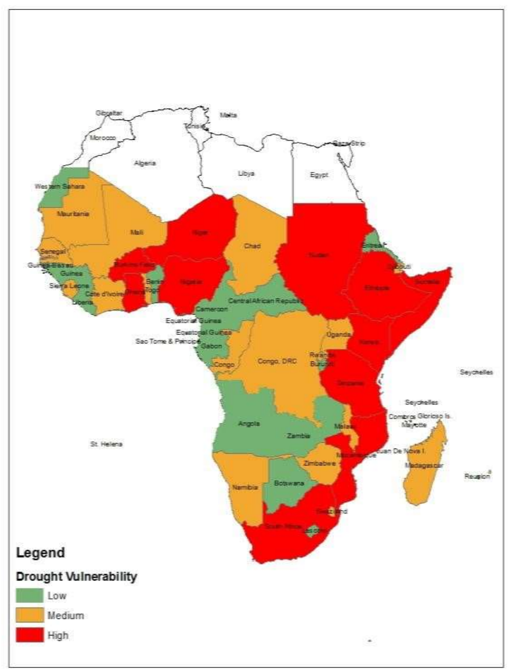
This method has provided a list of priority countries at high climate risk, which have been crosschecked with other factors such as significant investments (from World Bank and others) that could benefit from insurance and underdeveloped insurance markets. These countries are: Ethiopia, Kenya, Niger, Mozambique, Madagascar and Nigeria.

The maps below[5] represents vulnerability to floods, droughts and storms in SSA countries.

[5] Maps showing vulnerability of sub-Saharan African countries to floods, droughts and storms (cyclones) based on climatological factors: high – red; medium – orange; low – green.







Maps [clockwise] showing countries with the highest socio-economic vulnerability AND risk of adverse impacts from Flood, Droughts and Storms, Source: IMC

Insurance instruments for SSA

Existing insurance penetration in SSA is very low across all sectors, but particularly for property/catastrophe lines. Development of micro-insurance has been largely limited to health and life rather than coverage for weather risks, with the latter confined to a number of pilots or relatively low-volume schemes for weather index insurance products.

Sovereign risk management tools are rare, although several countries do have state-backed agricultural insurance schemes. These schemes tend to be inefficient and cover relatively few people.

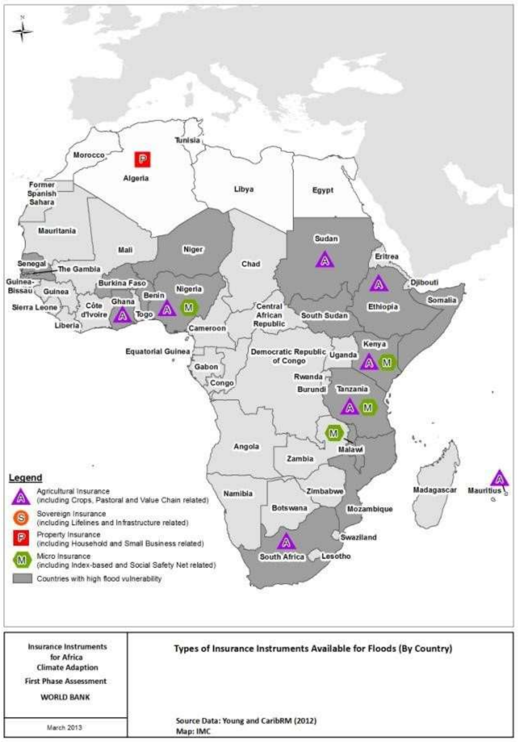
The mapping of insurance instruments in SSA countries (see figures below) as part of this project, reveals that there is ample scope to innovate and enable insurance instruments for new and nontraditional sectors and investments which are critical to sustainable growth within SSA.

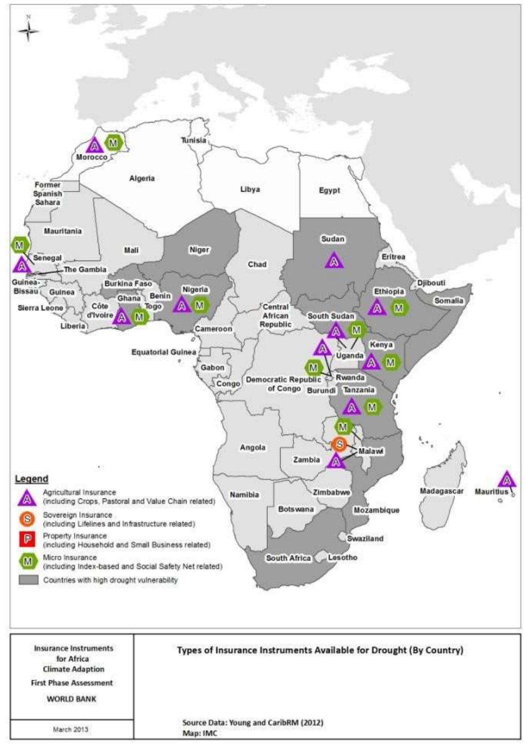
While changes in weather risk are likely to be felt most acutely in the agricultural sector across SubSaharan Africa, insurance tools can also address other emerging risks such as urban flooding, as well as particular sectors critical to economic development, such as the green energy sector and micro, small and medium enterprises.

While conventional insurance market penetration is likely to increase as economic development proceeds across Africa, significant innovation is required to fully integrate insurance tools into a comprehensive disaster risk management strategy which is critical as a foundation to sustained growth across the continent in the face of an increasingly hostile climate.

Developing the insurance market has a number of co-benefits that can improve the adaptive capacities of the shortlisted countries. The infrastructure needed for the development of insurance markets is also required for building adaptation capacity; the most prominent being financial strategy development and improved weather data infrastructure on precipitation/temperature/seasons. In addition, mainstreaming insurance brings co-benefits to adaptation such as raising risk awareness amongst the population, reducing financial losses from weather events and transferring the financial risk more widely where the sovereign itself is unable to cope with it.

Finally, an outline road map in this report has been described in order to elaborate the underlying requirements for the successful design, implementation and impact monitoring of insurance instruments in the shortlisted SSA countries.





Maps [clockwise] showing countries with Insurance related to Flood, Droughts and Storms as mapped during this study, Source: IMC

1. INTRODUCTION

Risk transfer instruments, including insurance, are increasingly relevant in improving the resilience of sovereigns and communities in dealing with weather risk to lives, vital assets and investments. Risk transfer, however, may not be a permanent solution – it needs to go hand-in-hand with adaptation in all sectors that are impacted by extreme and unpredictable weather. This requires innovation and development of instruments that are fit-for-purpose and affordable. Within this context the World Bank has commissioned the '*Insurance instruments for Africa Climate Adaptation*'[6] (amongst a cluster of other related projects) to assess the potential to enable the development of suitable insurance and insurance-like markets within Sub-Saharan Africa (SSA). In the first instance these will be applied in countries that the project has shortlisted as highly vulnerable to floods, droughts and storms. Some of these countries already have an established insurance market whilst others may require suitable conditions enabling them to develop further.

1.1 Project Objectives

This study is expected to contribute significantly to supporting African nations in finding innovative approaches to building resilience to historical climate variability and climate change. The World Bank is working on initiating regional programmes of support to climate risk management (working with the African Union (AU) and many Regional Economic Community/Basin Organisation partners) and specifically on providing technical assistance on climate insurance to selected countries.

This synthesis report aims to provide a clearer understanding of which SSA countries are at highest risk from floods, droughts and storms and could benefit from the use of insurance instruments. SSA is a fast growing region and it is safe to say that assets and investments in multiple sectors are at risk.

Insurance instruments [7] are becoming increasingly important for improving the resilience of governments and communities in dealing with weather risk to vital assets and investments. This project is a significant part of a cluster of projects currently underway at the World Bank to operationalise 'Disaster Risk Financing and Insurance - DRFI' in SSA countries (ongoing projects are shown in Table 1.1 below).

Activity	**Country**	**Lead World Bank Departments**	**Description**

[6] The 'Insurance Instruments for Africa Climate Adaptation' is currently in the first of two phases[1] in supporting African nations in finding **innovative approaches to building resilience to historical climate vulnerability and climate change.** Phase 1: *Identification of priority country clusters in Sub-Saharan Africa (SSA)* and Phase 2 is *In-depth Analysis of the Potential Feasibility of Climate Insurance Programs of Specific Hazards and Country Clusters*.

[7] Insurance can be defined as a set of instruments through which risk is ceded to a third party

Africa Insurance Instruments for Climate Adaptation	Africa	SDN	This is a study that will undertake a detailed assessment of climate risk exposure and vulnerability information (focusing on drought and flood), and existing insurance instrument foundations. This is expected to inform a more detailed technical assistance phase of work on facilitating the further development and adoption of such instruments to improve climate resilience in Africa.
Activity	**Country**	**Lead World Bank Departments**	**Description**
Africa Risk Capacity Feasibility Study	Africa	Treasury, AFTFP, FCMNB	Feasibility study for the design of a regional mechanism for sovereign disaster risk financing in SSA countries (complete).
Disaster Risk Financing and Insurance Country Reviews	Ethiopia, Malawi, Mozambique, Senegal, Togo, Mali, Burkina Faso, Ghana, Madagascar	AFTWR, GFDRR.	Reviews of disaster risk financing and insurance in GFDRR priority countries including fiscal management of disaster losses and insurance markets. Options for future development in this area are laid out.
South Africa Disaster Risk Financing and Insurance Program	South Africa	FCMNB	Feasibility study for disaster risk financing and insurance in South Africa.
Regional Approach to Developing the Insurance Sector	Africa	AFTFP, FCMNB	Technical assistance project that focuses on addressing the following areas for insurance development in SSA countries: regulatory reforms; institutional capacity building; market infrastructure and capacity; and consumer awareness and protection
Microinsurance Development Program (MIDP)	Global	FCMNB, IFC	Technical assistance and investment program aimed at improving access to transparent and reliable microinsurance products and services. The MIDP will support five mutually reinforcing sets of activities: (i) consumer awareness; (ii) investing in new product development and building market infrastructure (including building a global database on microinsurance); (iii) building public private partnerships (PPPs) to deliver microinsurance services for the poor; (iv) strengthening the enabling legal, regulatory and supervisory environment for inclusive insurance markets; and (v) catalysing investments in microinsurance providers and/or intermediaries.

Global Index Insurance Facility (GIIF)	ACP countries	FCMNB, IFC	The objective of this program is to fund countrylevel technical assistance programs that develop solutions that enable the scale-up of index insurance, design new index insurance products, and build the capacity of insurance companies and distributors in the field to be able to offer index insurance products on a sustainable commercial basis.

Table 1.1 World Bank projects

Implementation of these types of insurance instruments in a way that provides the most value to those countries within the region affected by climate change-based events will require innovation and development of long-term instruments that are fit-for-purpose and affordable within a developing nation context. This report aims to consider the implications of applying such strategies to priority countries which are highly vulnerable to floods, droughts and/or storms, while also providing a detailed analysis of the role of weather insurance in those specific countries and within the region.

Within this context, the World Bank is assessing the potential for enabling the development of suitable insurance programmes and markets within Africa. In the first instance, assessment will be restricted to countries that the project has shortlisted as highly vulnerable to floods, droughts and/or storms. Some of these countries already have an established insurance market while others may need enabling interventions to develop them.

This report aims to assess how insurance instruments could work in these priority countries within Africa. The definition of priority countries detected through the evidence and research carried out for this project has been based on climate vulnerability, strategic investment and existing insurance market status.

1.2 Typical Insurance Landscape: What to Expect?

While it is hard to make a generalisation, sector experience points to components of the insurance landscape that are key elements in establishing successful insurance markets. *Figure 1* depicts these key elements in the context of mainstreaming insurance, these are defined as follows:

Socio-economic base: This is the cumulative social and economic standing of the country often described through a number of disaggregated indicators such as GDP [Gross Domestic Product] and HDI [Human Development Index]. This study provides a socio-economic ranking of countries in the SSA region. The impacts on this base from extreme weather are termed as *losses*.

Relevant insurance: Established insurance markets rely on insurance products that are either mandatory and/or relevant to the client. Potentially, the types of investments and assets that could benefit from insurance are numerous, however, the insurance industry has traditionally operated within four general categories: agriculture, sovereign, property/catastrophe and microinsurance (being the latest addition) Despite tradition, it is important to approach the potential of insurance in

Africa with an open mind as there are many assets and investments that are at risk from weather events for which innovative products could be developed.

Insurance is not the only tool to transfer weather risk - financial losses can also be compensated through savings, for instance, to avoid a decline in living standards or the failure of a service such as staff payments. Thus insurance is most relevant when other options are ruled out as inadequate to compensate for the level of losses.

Stakeholders: For the purposes of this assessment three types of stakeholders are defined. The potential buyers of insurance – the 'clients'; the re/insurance 'providers' - those who provide the cover against weather risk losses and the 'regulators' who define the legal and operational framework for insurance to be conducted

Client value: This is perhaps the biggest lesson from ongoing experience in seeding new insurance markets. As previously mentioned, unless insurance is mandatory it needs to be relevant in the perception of the clients. Client value is defined from the client's perspective rather than the seller's perspective. 'Value is created when clients use the product and are satisfied enough to renew their policies' (Munich Re, 2012).

Often insurance providers sell products which have little relevance to the client or are far too demanding for the context, thus failing to take a foot-hold in the market. According to Karamchandani et. al. (2009) '*The most common mistake among unsuccessful market-based solutions is to confuse what low-income customers or suppliers ostensibly need with what they actually want. Many enterprises have pushed offerings into the market only to see them fail. People living at the base of the economic pyramid should be seen as customers and not beneficiaries; they will spend money, or switch livelihoods, or invest valuable time, only if they calculate the transaction will be worth their while. Low uptake rates may suggest that many of the agricultural insurance products that have been offered are simply not desirable to clients*.'

Re/Insurer value: The Re/Insurance sector itself is highly risk averse. Traditional (indemnity) insurance products are designed according to basic principles that apply to the concept of economic loss. In order for a risk event resulting in economic loss to be consider insurable, it must have the following basic characteristics.[8] Note, however, that these principles may not all be relevant or applicable to newer index based forms of insurance:

1. The event must be random (occur purely by chance).
2. The loss (assumed at the start) must be definite in terms of timing and amount.
3. The loss must be causing significant hardships for instance for the household.
4. The rate of loss must be predictable.
5. The loss must not be catastrophic to the insurer[9].
6. A large number of persons (or assets) with similar[10] risk characteristics must participate.
7. Premium rates must be affordable otherwise it is not an accessible financial service.

In summary insurance providers are unlikely to pursue markets or products where the estimate of potential losses cannot be determined or there may be significant financial losses.

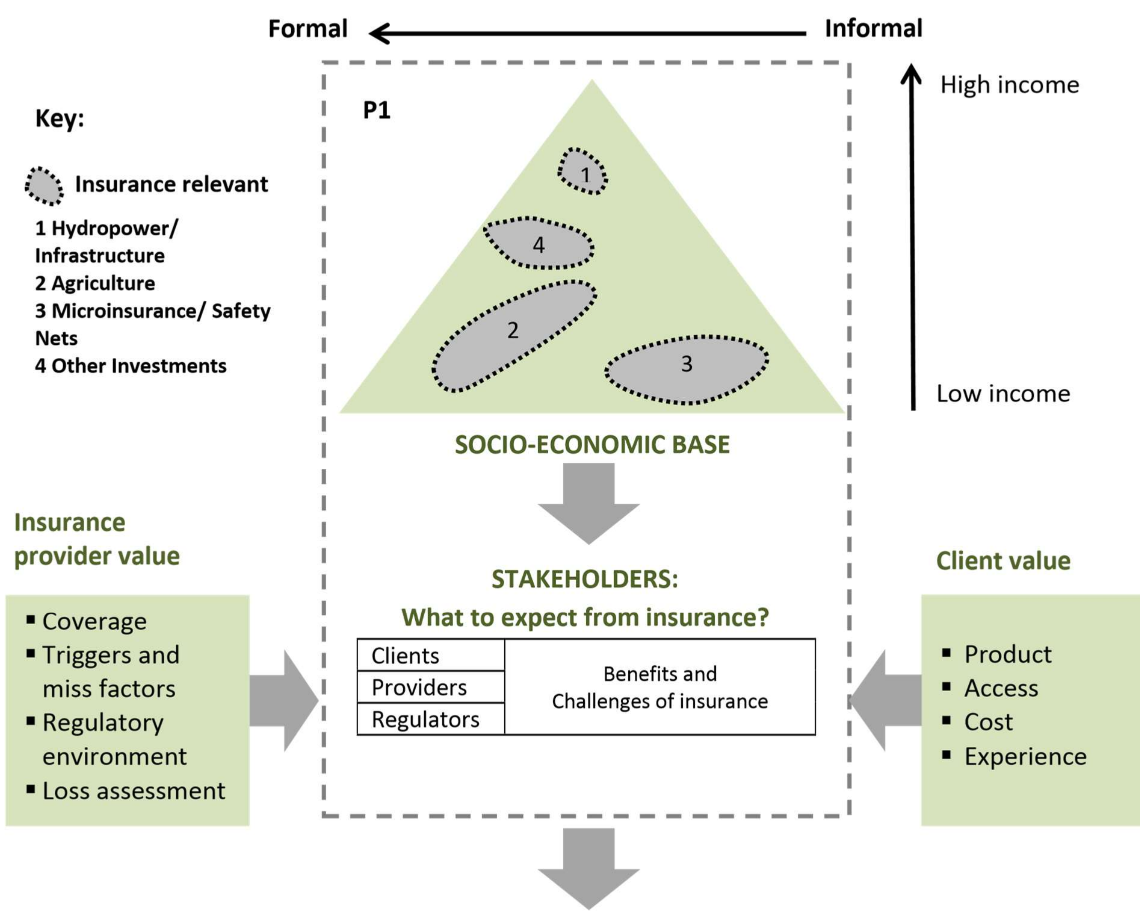
[8] ADA 2012

[9] Unless they have reinsurance

[10] Mostly true in the microinsurance context.

Operational context: These are all the contextual issues that re/insurers consider before entering markets and developing suitable insurance products. The list below is adapted from Swiss Re's 2012 assessment of the insurance market in Africa.

Figure 1: Insurance landscape for a typical country, Source: IMC



INSURANCE OPERATIONAL CONTEXT
Economic growth
Culture & Religion
Education
Property rights
Distribution channels
Political stability
Wealth distribution
Risk awareness
Legal framework

2. INSURANCE IN DISASTER RISK MANAGEMENT

2.1 Disaster Risk Financing and Adaptation

The countries of Sub-Saharan Africa (SSA) are highly exposed to a range of natural events, with hydro-meteorological events having the largest impact. The number of disasters reported in Africa has shown an upward trend since the 1970s, with Sub-Saharan Africa experiencing more than 1,000 disasters within the last four decades, with 300 of these disasters occurring between 2005 and 2009 alone (World Bank, 2012).

The corresponding social and economic losses associated with these events have also increased over time due to increases in population and assets exposed to adverse natural events as a result of rapid urbanisation and environmental degradation. Coping with these disasters has been a challenge for households, businesses and governments in these countries. In addition to the high human toll, enormous budgetary constraints are created as financing needs increase dramatically with the corresponding need to undertake relief, recovery and reconstruction activities.[11]

This situation is further exacerbated by the fact that generally, disaster risk management in most Sub-Saharan African countries suffers from inadequate financial support and challenges in the deployment of those funds that are available. Due to the low priority accorded to disaster risk management in budgeting at the national and local levels of government, there is often a lack of dedicated funding mechanisms for disaster risk management and limited insurance penetration restricting the contribution of the private sector to this agenda.

Most national disaster risk management authorities have some provision for financing national disaster management plans but the approaches vary, reflecting the different national circumstances in the region. Approaches range from mere indications of the intention to finance the disaster risk management system through to legislative earmarking of funding. A lack of ex-ante planning for the deployment of funds (e.g. contingency plans) is also a strong limiting factor in the development of resilience.

Strategies and mechanisms for financial protection against disasters can reduce the impact and even the overall cost of disasters on developing countries by taking pressure off fiscal and individual budgets in the aftermath of a disaster. Mechanisms that provide rapid, cost-efficient liquidity to governments or individuals can ultimately reduce the cost of disasters by preventing a resort to adverse financial coping mechanisms, such as high-interest borrowing, and by accelerating recovery. Furthermore, timely liquidity can be critical in saving lives. This was evidenced by the Horn of Africa drought disaster of 2011, where an estimated 50,000 to 100,000 lives were lost as a result of the disaster, and according to multiple humanitarian agencies, the death toll was significantly increased by the delay in funding of food aid by many months (despite accurate forecasting of the need).

An additional challenge within the context of Sub-Saharan Africa is the fact that there is often an extensive dependence on financing from international donors for post-disaster needs. While ex-post disaster funding from bilateral and multilateral agencies can be an important part of a government's

[11] In 2011 total global economic losses due to disasters reached an estimated USD 370 billion, yet according to Swiss Re's Chief Economist Kurt Karl, natural catastrophe insured losses came to just a third of this, at around USD 110 billion. Two thirds of this economic damage was instead borne by corporations, governments, relief organisations, and individuals; illustrating the widespread lack of insurance protection worldwide.

catastrophe risk management strategy, over-reliance on this approach has major limitations. Donor assistance can take a long time to materialise and usually supports investment projects, with limited possibilities of financing budget outlays such as the immediate costs of reconstructing lifeline infrastructure.

Developing a risk financing strategy is therefore an important part of a broader comprehensive disaster management strategy. Although it is often argued that financial protection strategies treat the symptoms but not the cause of disasters, good strategies can help governments cope with the financial impact of calamities and allow 'space' for the causes to be addressed. However, a comprehensive risk management strategy should cover many other dimensions, including programmes to better identify risks, reduce the impact of adverse events, and strengthen emergency services (See Figure 2.1).

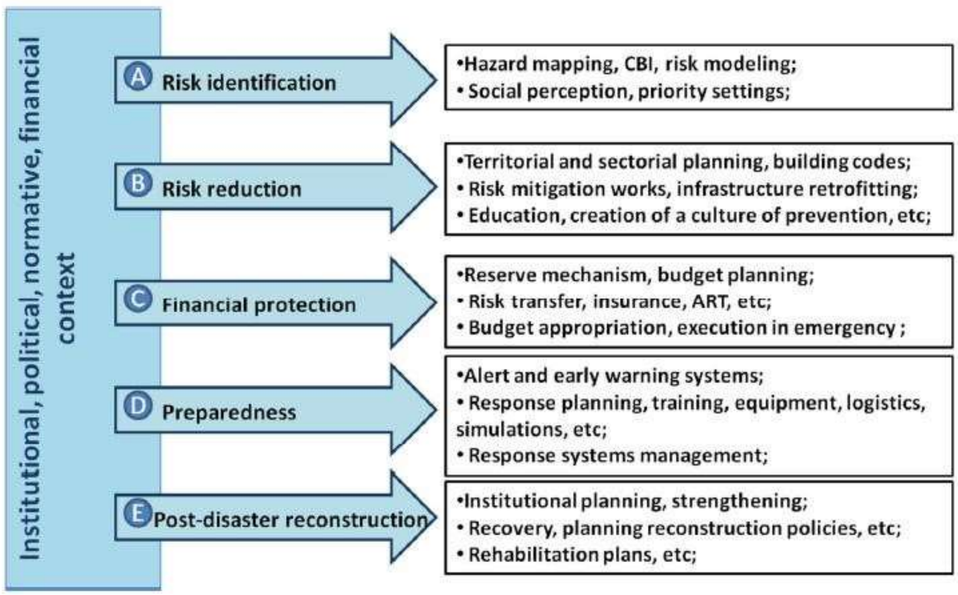


Figure 2.1 Comprehensive disaster risk management strategy
Source: Ghesquiere, F., and O. Mahul (2010). Financial Protection of the State against Natural Disasters: A Primer. World Bank Policy Research Working Paper # 5429

A variety of instruments can be considered in the establishment of a risk financing strategy. These can be classified as ***ex-ante risk financing instruments*** such as the building of financial reserves, contingent debt agreements and insurance (and alternative risk transfer solutions), and ***post-disaster*** or ***(ex post) risk financing instruments*** including tax increases, reallocating funds from other budget items, access to domestic and international credit, and borrowing from multilateral finance institutions.

In developing a disaster risk financing strategy it is important to keep in mind that there are significant differences in the risk profiles of different perils in Sub-Saharan Africa. Different risk profiles call for different disaster risk financing instruments and strategies. The risk profiles for the perils of drought and flood tend to be characterised by a large portion of losses through higher frequency / lower severity events (i.e. events with relatively small individual impacts but which occur often). This is different from the risk profile of other natural disaster events such as cyclones or earthquakes, which are typically characterised by large events with high costs incurred on an infrequent basis.

Figure 2.2 shows the difference between the risk profiles of hurricanes in Jamaica and the First Rangeland season for drought in Ethiopia as a case in point. On average (as measured by the average annual loss), the two perils are almost exactly equal in terms of causing losses. However, as can be seen, for Jamaica hurricane risk, costly events happen at the low-frequency (high return period) end of the return period scale. For Ethiopian drought risk, the curve is flatter, with costly events happening more quickly in the high frequency (low return period) area of the return period scale. A range of risk profiles can be seen between regions in a country and certainly between countries, as well as between different perils.

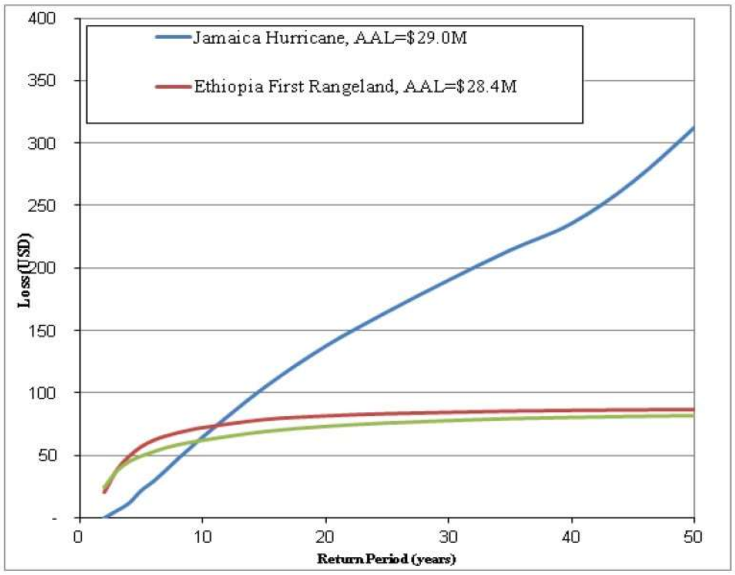


Figure 2.2: Risk Comparison: Jamaica hurricane risk vs. Ethiopian drought risk
Source: African Risk Capacity: A Study on the Feasibility of a Regional Approach to Financing Drought Risk in Africa, World Bank (Draft, August 26, 2011)

Furthermore, there are important distinctions between, for example, droughts and flood in terms of risk management/financing approach, including: (i) drought is a slow and delayed onset event, whereas floods have the potential to onset rapidly (ii) floods are often characterised by infrastructure damage while drought is not. The management solutions to these risks could therefore be quite different. Insurance tends to represent higher value for more severe, less frequent events while risk reduction has more direct impact on frequency of loss or the amount of loss in frequent events.

While a wide range of instruments exist to finance long term expenditures ex-post, the financing of short term needs is more challenging. Figure 2.3 depicts potential financial gaps between the available budget and various needs after a disaster and how ex-ante financing instruments can fill these gaps.

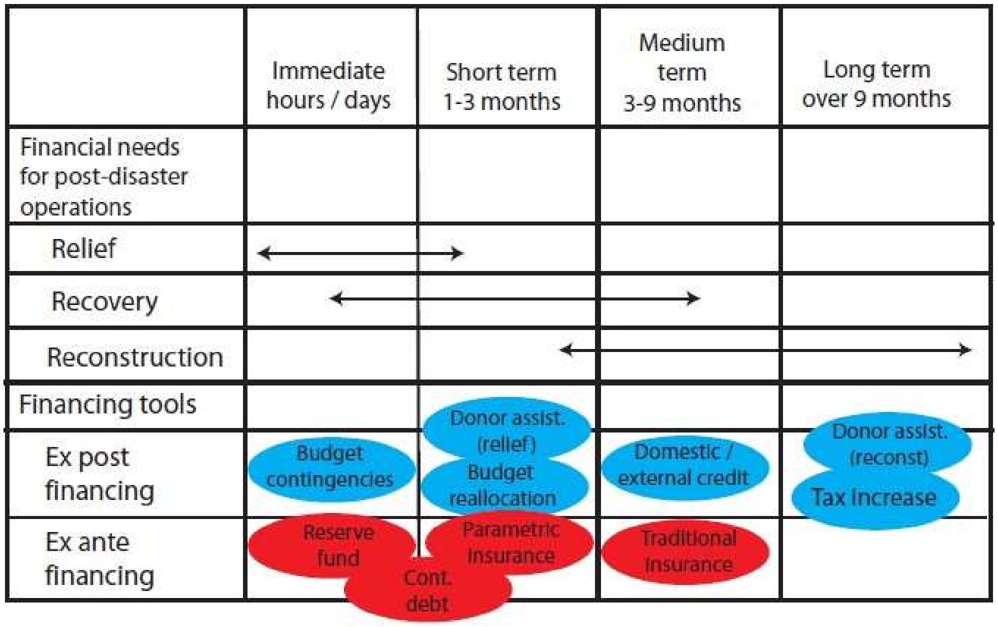


Figure 2.3: Availability of Resources after Disasters

Source: World Bank (2008). Operational Innovations in Latin America and the Caribbean, The Caribbean Catastrophe Risk Insurance Facility: providing immediate funding after disasters. Volume 2, Number 1.

Catastrophe risk layering can be used to design a risk financing strategy (see Figure 2.4). Budget contingencies together with reserves are the cheapest source of ex-ante risk financing and will generally be used to cover the recurrent losses. Other sources of financing such as contingent credit, emergency loans and possibly insurance should enter into play only once reserves and budget contingencies are exhausted or cannot be accessed fast enough.

A "bottom-up" approach for sovereign risk financing is therefore generally recommended. The government first secures funds for recurrent disaster events and then increases its post-disaster financial capacity to finance less frequent but more severe events, potentially via risk transfer. The level of fiscal resilience to natural disasters, which drives the optimal financial strategies against natural disasters, is a decision to be taken by the government based on economic and social considerations. While sovereigns can directly manage contingent liabilities through a variety of instruments at the national level, market development and the expansion of insurance, alongside risk reduction, at the individual and community level can shift the majority of the burden from the State to the private sector.

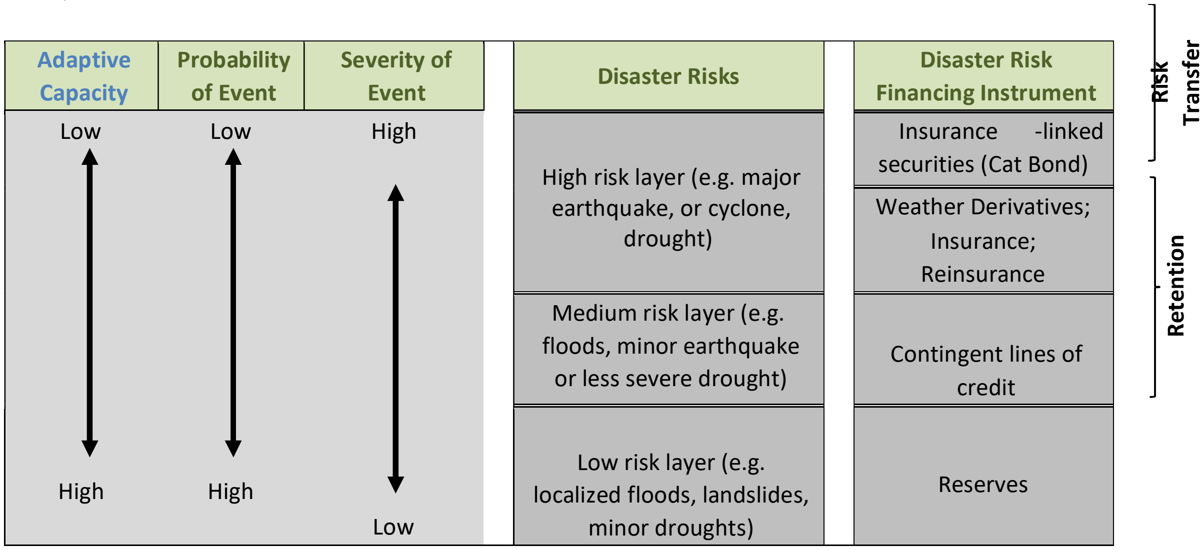


Figure 2.4: Adaptive Capacity & Insurance, Source: Interpreted from Disaster Risk Financing and Insurance in Sub-Saharan Africa: Review and Options for Consideration. World Bank, November 2012.

The World Bank advocates a three-tiered layered approach to the development of financing arrangements to cover disaster losses. Different disaster risk financing instruments (DRFI) will be suitable for different layers of risk, depending on their cost of use, speed of disbursement and the volume of funds that can be made available through the mechanism. Vellinga and Mills writing in 'Insurance and other financial services' (IPCC, 2011) point to the co-benefits of promoting insurance markets in the context of weather risk adding that 'more-extensive penetration of, or access, to insurance would increase the ability of developing countries to adapt to climate change. More widespread introduction of micro-financing schemes and development banking also could be an effective mechanism in helping developing countries and communities adapt'.

Figure 2.4 outlines the World Bank framework for DRFI at the macro level, but has added a dimension of *adaptive capacity* - this is the ability of a system to avoid deterioration under the adverse impacts of weather. Overtime adaptive capacity manifests itself into physical or behavioural outcomes known as adaptation (Smit & Wandel, 2006) and while this takes its course, insurance can be applied to cover the risks to a system under adaptation, particularly those that cannot be predicted. From this it is possible to infer that insurance protection may not be a permanent state, however, it is useful in covering various aspects of the socio-economic base that are building up their adaptive capacity which are particularly vulnerable to low-probability, high-impact events. Field experience of World Bank personnel also indicates that some insurance instruments are best applied as short-term protection measures.

Analysis of the costs and benefits of instruments concludes that risks associated with high-frequency, lower-cost events occurring on a near-annual, recurrent basis should be met via regular annual budget allocations or the establishment of reserve facilities using budgetary (and other) resources.

Further funding for slightly larger events can be raised via the post-disaster reallocation of budgetary resources and the realignment of national investment priorities, although this can carry a higher opportunity cost and detract from the development agenda. There are a number of options for intermediate level events including the use of contingent credit and contingent grant windows, depending on the borrowing capacity of the country in question. The highest layers of risk associated with low-frequency, high-cost events should be transferred to third parties via a mixture of more expensive insurance or alternative risk transfer tools such as derivatives. It is important to recognise that some market risk transfer is not designed to provide complete coverage for extreme events, but to provide immediate liquidity in the sovereign context. For the most extreme events, reliance on international assistance will often remain a necessary.

Governments, the private sector and the international community play important roles within all of these layers. For example, for intermediate and higher layers of risk, the private sector and international community provide additional risk-bearing capacity, where it is not cost-effective or feasible, for disaster losses to be managed using governments' available financial resources. There are also examples of the international donor community using national reserve funds as channels to contribute to countries' financial resilience, as is the case for the Disaster Assistance Emergency Fund of the Republic of Marshall Islands.

Box 2.1: World Bank acting as intermediary

In October 2012, Executive Directors of the World Bank approved a proposal to extend intermediation of natural disaster risk management products. This proposal, which is part of the broader agenda of mainstreaming disaster risk management, complements existing tools such as IBRD's Catastrophe Deferred Draw-Down Option and IDA's Crisis Response Window and Immediate Response Mechanism. Specifically, the new authorisations allow the Bank to expand intermediation services to include derivatives to hedge geological and meteorological events, in addition to weather events, and to expand the offer of these products to client countries, their sub-national entities, and regional and international organisations.

When intermediating on behalf of countries, the Bank stands between the member country and the private sector, engaging in back-to-back transactions with both parties to pass on the terms of the risk protection from the market counterparty to the client while providing protection to the member country against the credit risk of the private sector counterparty. Member countries benefit by being able to leverage private sector risk capital to manage the impact of natural disasters and by being able to make use of the World Bank's technical expertise and standing in the financial markets.

2.2 Insurance Tools in Disaster Risk Management

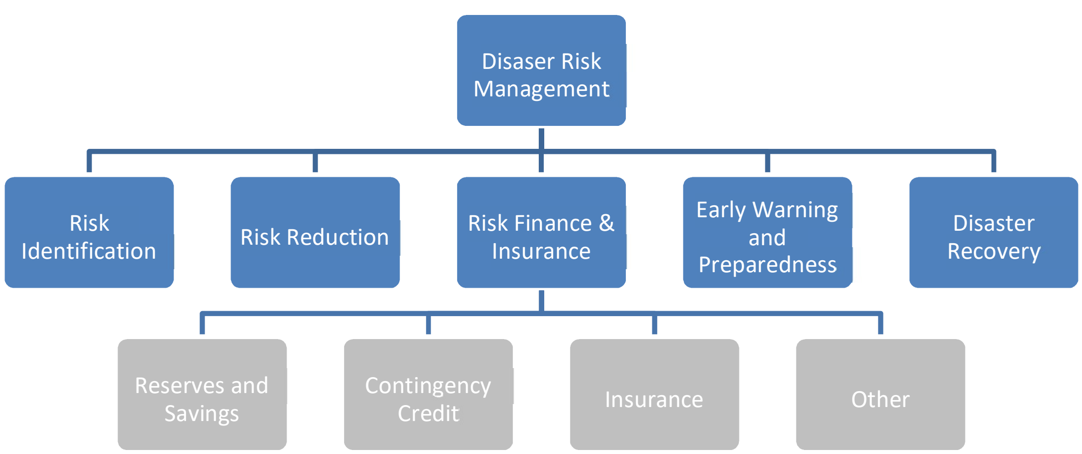


Figure 2.5 Insurance Tools in Disaster Risk Management, Source: IMC

Insurance is an ex-ante risk financing instrument which has been identified as a key component of the Hyogo Framework of Action Priority #4, and one of the five pillars of the framework for disaster risk management (DRM) (see Figure 2.5) promoted by the World Bank.

Disaster risk reduction aims to reduce exposure and vulnerability to natural hazard risks and in some cases the probability that they will occur, whilst risk transfer aims to reduce the losses suffered after the event. Insurance cannot directly prevent the loss of lives and assets and on its own it is not the solution. It is, however, an important component of a comprehensive disaster risk management strategy and can incentivise and promote disaster risk reduction measures.

Suarez and Linnerooth-Bayer in the *Global Assessment Report on Disaster Risk Reduction* (2011) have listed the following familiar ways in which insurance instruments can be an integral part of risk reduction outside the disaster area:

- *Enable loss-averting measures after the event (e.g. health insurance covers hospital expenses that might otherwise be prohibitively expensive after an accident);*

- *Provide necessary safety nets (e.g. unemployment and "social" insurance schemes allow low wage workers to start promising but risky business ventures pulling them out of "working poverty" and reducing their vulnerability);*

- *Convey price signals that incentivize risk reduction (e.g. car owners may be more inclined to install an alarm system if this reduces the cost of theft insurance premium)*

- *Stipulate risk reduction behaviour (e.g. house buyers can be required to install smoke detectors to be eligible for a mortgage); and*

- *Enable vulnerability reduction (e.g. without liability insurance, ambulance personnel may refuse to engage in risky but often life saving interventions)*

In the case of Disaster Risk Reduction there are a couple of ways in which insurance might incentivise risk reduction. If linked to the forecast of an event that can cause catastrophic damage it can provide funds for pre-disaster risk reduction activities. For example, in Peru insurance arrangements linked to seasonal rainfall forecasts allow retrofitting investments to minimise damage weeks before the (predictable) El Niño occurs. Moreover, risk management initiatives can link risk transfer with risk reduction, as done in Ethiopia, by offering cash constrained farmers the option of paying their insurance premium with disaster risk reduction focused labour (see case study in Chapter 5). Risk reduction can also be incentivised through price signals and risk management stipulations. For example, contracts could stipulate that certain risk reduction mechanisms, such as the adoption of wind-resistant cropping patterns or drought-tolerant crop varieties, must be in place if crops are to be covered.

Insurance instruments can also help build adaptive capacity (Hellmuth, Osgood, Hess, Moorhead and Bhojwani, 2009). A comprehensive strategy for adaptation in the agricultural sector could, for example, include adapted crop varieties, micro-irrigation, rainwater harvesting, and improved soil conservation practices. However, a certain amount of risk will inevitably remain.

The second way index insurance can contribute to adaptation is through building more resilient livelihoods by enabling access to increased credit, technology and inputs. Insured loans allow lenders to recuperate their money even in a year where the climate causes production losses. The loans allow people to invest in more intensive livelihood strategies which may help them to escape poverty traps. The increase in wealth and in economic resilience allows people to buffer themselves from the direct impacts of the climate.

The World Bank promotes a proactive approach to the financial management of risks to agricultural production, as one component of a comprehensive disaster risk management approach. This focuses on dealing with the impact of residual risks that remain after cost-effective risk mitigation techniques (e.g., irrigation, pest treatments) have been implemented. In this framework (see figure 2.7 below), agricultural risk financing – including insurance, credit and products to manage price risk (forward sales, futures contracts and options) – is presented as one key risk management pillar alongside institutional capacity building, quantitative assessment of risks to agricultural production and agribusiness segmentation.

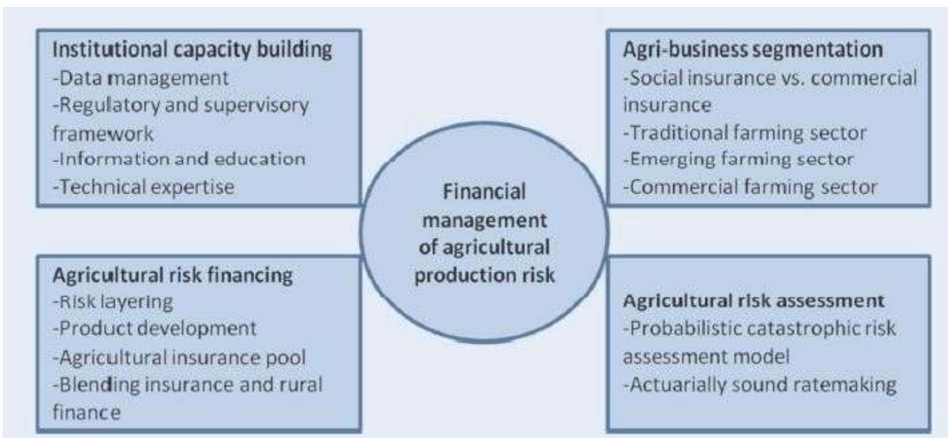


Figure 2.7: World Bank framework for the financial management of agricultural production risk, Source: World Bank Disaster Risk Financing and Insurance programme.

Box 2.2: When to use insurance for weather related socio-economic impacts (losses)

The re/insurance sector brings the benefit of actuarial and statistical sciences to bear upon Disaster Risk Management. In particular the sector is becoming highly skilled at understanding the correlation between multiple weather events, economic activity and their socio-economic impact or losses. Extreme weather can cause damage and create financial stress for individuals, communities, institutions, physical assets and services. The choice of financial instrument is highly dependent on the context. The insurance sector, particularly the private sector operated re/insurance, prefers to operate where losses can be clearly defined and there is also the requirement of keeping business profitable and financially sound. The insurance industry also has substantial operational requirements not least of which is the availability of weather information (historic or calculated models) in order to determine the probability of weather events and resulting losses.

Current trends thus suggest that insurance may be useful where many of these conditions are met:
-Socio-economic losses are well above what savings or contingency funds could have covered.
-The extreme weather events causing the losses are highly improbable.
-The capacity to adapt to extreme weather is low or growing at a slow pace

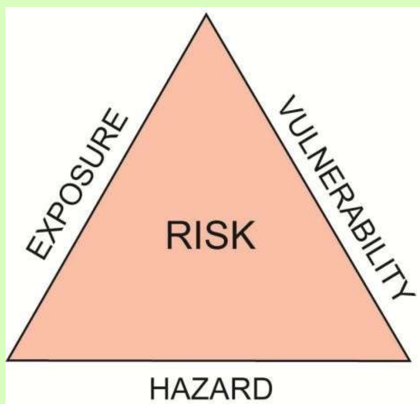


Figure 2.6: Risk Triangle[1]**.** Source: Middelmann M.H (eds.,) (2007) Natural Hazards in Australia: Identifying Risk Analysis Requirements, Geoscience Australia, Canberra

Crichton (1999)[2] described risk in disaster management as the probability of a loss that depends on these three factors. He represented this as a triangle (see Figure 2.6). The area inside the triangle represents risk and the sides of the triangle represent the three independent factors that contribute to risk: hazard, exposure and vulnerability.

[2] Crighton, D. (1999) The Risk Triangle in Natural Disaster Management, Ingleton J. (Ed). *Natural Disaster Management*,

Box 2.3: Property Insurance and Adaptation

The following are some key considerations in assessing the role of traditional property catastrophe insurance in climate adaptation (Lloyd's, 2008):

Adaptation is key to ensuring future insurability: Risks arising from natural catastrophes are insurable but adaptation measures are vital to maintain the availability of affordable insurance, particularly for existing coastal properties. Adaptation methods could include elevating properties, reinforced cladding and flood defences such as sea walls. No single approach provides full protection against all losses, and combinations of adaptation measures are essential to provide maximum protection levels. However, there is a cost attached to adaptation which governments and policyholders must consider. Individuals and businesses may need incentives to take adaptation seriously.

Society, business and the insurance industry must be flexible in their response to climate change: Climate change projections are uncertain and a wide range of scenarios should be considered when planning for the future. Climate change models must be constantly updated to reflect evolving scientific information and society should build them into adaptation decisions.

Household and business property valuations should take account of levels of future risk: A property which has been adapted is more valuable because the risks for the home or business owner are reduced. In some areas where defences are not introduced or maintained, properties could lose value if they are uninsurable, and the withdrawal of private insurance coverage could be followed eventually by a 'managed retreat' from the highest risk areas by property-owners.

The insurance industry has a key role to play in promoting adaptation: By setting premiums at a level which reflects the underlying risk, insurers promote the concept of risk-based pricing and enable individuals to understand their risk profiles better, and the costs and benefits of investing in adaptation components.

Better quality data will help the insurance industry to conduct more accurate risk analysis: All parties involved in the insurance chain must drive for much improved data quality and geographical resolution in order to allow full and proper risk analysis.

Climate change is only one of several emerging trends driving risk: Socio-demographic factors such as population increases, and the growth of urban areas in coastal and other exposed zones often combine with climate change to exacerbate risk. Adaptation strategies must not be developed in isolation from these factors and must take account of them.

2.1 Importance of Insurance in the Context of Informal Coping Mechanisms

Risks to life and livelihood from shocks in poor, low-resource settings require efficient safety nets to prevent loss of welfare and undesirable development outcomes. Across most of the developing world including the largely primary-sector oriented Sub-Saharan African economies, access to formal markets of credit and insurance continues to be limited. While this calls for integrated policy action to ensure greater penetration of formal market institutions and wider financial inclusion, a proper understanding of the functioning of informal, non-market-based exchanges and the role of sociocultural institutions in helping the persistence of indigenous systems of risk-pooling is equally essential.

The theoretical as well as empirical literature on the interactions between climate change risks, informal coping mechanisms and local adaptive practices, provide important insights on the rationale of, and gradients explaining, the importance of informal insurance instruments. In a background paper to the UNDP's Human Development Report 2007/08, Osbahr[12] points out that local experiences offer important lessons for national governments wishing to support adaptation strategies, as people in the face of risks adapt to climate variability and change on a daily basis and act positively to enhance their resilience to livelihood stresses. In his review of the role of coping mechanisms and safety-nets against multifarious shocks (that includes weather variability, and long-term adverse climate) in East African communities, Dercon[13] argues that households have developed sophisticated risk-management and risk-coping strategies including self-insurance via savings and informal insurance. This is largely to compensate for missing or incomplete insurance markets, due to the presence of high insurable risks and cultural barriers. In his theoretical model, Dercon argues that self-insurance via savings are clearly beneficial when credit markets are imperfect; a rich literature in development economics indicate that although complete risk-transfers appear difficult, if not rare, for large populations through informal mechanisms, relatively complete risk-transfer may be possible through informal transfers and social networks in a micro-setting, or among homogenous groups such as tribes[4].

However, prevalence of self- and informal insurance does not mean such mechanisms are either efficient or effective in pooling risks both across communities and over time. For common or covariate shocks such as climatic hazards and long-term weather fluctuations, informal insurance mechanisms can assume different dimensions, as network-based risk-pooling and support systems can be nullified with shocks affecting entire regions and communities, rather than just individual households. As a result informal coping mechanisms may have limited or constrained usefulness in restoring normalcy. There are also clear risks that such common shocks may trigger more desperate informal coping mechanisms thereby posing larger welfare risks for vulnerable households and communities. Such gaps can only increase vulnerabilities and a failure to pool risks. Any exercise to explore insurance and risk-transfer tools against climate risks and variability can gain by accommodating both the potential and risks manifest in existing local adaptive mechanisms and informal insurance, and analysing the feasibility of compensating for potential risks of welfare loss in the prevailing risk-pooling mechanisms through formal, institutionalised measures.

SSA is now a high growth region and investments in multiple sectors are required to enable this growth. This includes urban infrastructure, energy, adaptation and development programmes which are equally prone to climate shocks and failures from catastrophic floods, droughts and storms. Informal coping measures are not appropriate for climate risk transfer related to such projects and programmes. Solution need to be found within the formal insurance markets or insurance-like partnerships between sovereigns.

It is strongly recommend to refer to Appendix 1 for illustrations of innovative projects in insurance and informal adaptation programmes that could benefit from climate risk transfer.

[12] Osbahr, H. (2008) Building resilience: Adaptation mechanisms and mainstreaming for the poor, HDRO Occasional Paper, *Human Development Report 2007/08 – Fighting climate change: Human solidarity in a divided world*, Accessed at: http://hdr.undp.org/en/reports/global/hdr2007-8/papers/Osbahr_Henny.pdf

[13] Dercon, S (2002), Income risk, coping strategies and safety nets, *The World Bank Research Observer*, Vol. 17, No. 2 (Fall 2002), pp.141-66. [4] Op. cit.

2.4 Overview of Insurance Tools

Risk transfer instruments are financial instruments through which risk is ceded to a third party. This can include instruments such as traditional insurance and reinsurance, parametric insurance (where insurance payouts are triggered by pre-defined parameters such as wind speed of a hurricane), and Alternative Risk Transfer (ART) instruments such as catastrophe (cat) bonds (Ghesquiere & Mahul, 2010).

Following the World Bank definitions and for the purposes of this section, which is focused solely on insurance instruments, we have classified the different types of insurance instruments which could possibly play a role in enhanced climate resilience through insurance mechanisms (i.e. address weather risk through transfer) into four broad groups:

- Sovereign disaster risk transfer;
- Agricultural insurance;
- Property catastrophe risk insurance; and Disaster microinsurance.

a) Sovereign disaster risk transfer
Sovereign disaster risk transfer instruments aim to increase the financial response capacity of governments in the aftermath of natural disasters, while protecting their long-term fiscal balances, through the use of risk transfer instruments including insurance and insurance-linked securities (e.g. catastrophe bonds, catastrophe swaps, and weather hedges). Building on a risk financing strategy, Governments are usually better served by retaining most of their natural disaster risk while using risk transfer mechanisms to manage the extra volatility of their budgets or to access immediate liquidity after a disaster (Cummins & Mahul, 2009).

b) Agriculture insurance
According to Mahul and Stutley (2010), ‘agricultural insurance is one of the financial tools agricultural producers can use to mitigate the risks associated with adverse natural events – events that climate change may render more frequent and more severe in the future’. These tools provide cover for catastrophes that impact crops and livestock and are most effective when applied within a framework for agricultural risk management.

There are different types of agricultural insurance but these are generally classified into two broad groups: traditional crop insurance products and index-based weather insurance products. Each is discussed further below drawing particularly on two excellent sources of information on recent developments in agricultural insurance which have been produced by the World Bank’s Agricultural Risk Management team; an agricultural insurance training manual (World Bank, 2010) and a guide to index insurance in agriculture for practitioners (World Bank, 2012).

i) Traditional crop insurance
Traditional agricultural insurance relies on the principle of indemnity – that is the insurance product responds to an actual loss by providing the amount required to replace that loss. There are two broad types of traditional insurance, namely:

Named Peril Crop Insurance (NPCI): This type of traditional insurance assesses losses that occur due to a specific peril(s) through field assessments. This makes it easy to determine actuarially-sound premiums as long as historical series of weather and loss data exists. NPCI is subject to moral hazard problems (which arise when insured parties alter their behaviour to increase the potential likelihood or magnitude of a loss) since farmers may not take appropriate precautions against crop damage because they are insured.

Multi-Peril Crop Insurance (MPCI): This type of insurance establishes an insured yield as a percentage of the historical average yield. If yield is less than the insured yield, an indemnity is paid. Yield guarantee insurance is attractive to farmers since it covers drought, flood, high winds, etc, but it has a number of weaknesses:

- May be actuarially unsound – essentially covering highly spatially correlated and uninsurable risks;
- In the case of plant disease and pest damage, hard to disentangle management failures from external factors;
- Normal premiums would be exorbitant, therefore government subsidies are often needed to increase farmer participation rates and it often ends up being an income transfer scheme disguised as risk management tool;
- Subject to adverse selection (which occurs when the potential insured has better information than the insurer about the potential likelihood or magnitude of a loss, thus using that information to self-select whether or not to purchase insurance) and moral hazard; and
- Costly to administer.

ii) Index-based products

These compensate farmers based on changes in an index (generally weather-related, but can include other factors) rather than an assessment of actual amounts of damage. The index acts as a proxy for yield and hence changes in the index should reflect changes in yield. There are two types of index based insurance products:

Area Yield Index: This type of insurance provides a payout based on realisation of an index that is highly correlated with farm-level yield short-falls. The indemnities are paid based on estimates of the yield in defined areas, e.g. a parish. A threshold is established that is less than the expected parish yield and indemnities are paid to all farmers whenever the realised area average is less than the threshold.

Weather-based Index Insurance: Indemnity is based on realisation of a specific weather parameter measured over a pre-specified period of time at a particular weather station. Payout occurs when the realised value of the index exceeds a pre-specified threshold or when the index is less than the threshold. This type of product is appropriate for highly correlated risks and where there is a strong, quantifiable relationship between weather risk and yield loss.

Since index based insurance does not indemnify the actual loss, its often touted advantage over traditional indemnity-based products is the fact that farmers are provided with disaster assistance shortly after the disaster/loss has occurred. The farmer therefore does not have to wait until the claim has been verified – thereby making this tool attractive to potential capital providers (Geneva Association, 2010). Low monitoring costs in turn lead to more affordable premiums; it is therefore often promoted as flexible instrument which is well suited to low income households. Index products are also not susceptible to adverse selection or moral hazard.

On the other hand, an important issue to keep in mind when reviewing and assessing agricultural index-based products is basis risk. Basis risk is the potential mismatch between contract pay outs and the actual loss experienced. This is the main disadvantage of index insurance products, and emerging research on the economic impact of basis risk (e.g. Clarke and Vargas Hill, 2012) provides insights to better design of products and particularly highlights the need for effective benefit distribution mechanisms.

Besides the issue of basis risk, this type of insurance is limited by its heavy dependence on quality and quantity information available for developing risk models of probable loss and is therefore often better suited for regions/countries with long historical weather data series, good coverage by weather stations, and easy access to satellite imagery.

c) Property catastrophe risk insurance

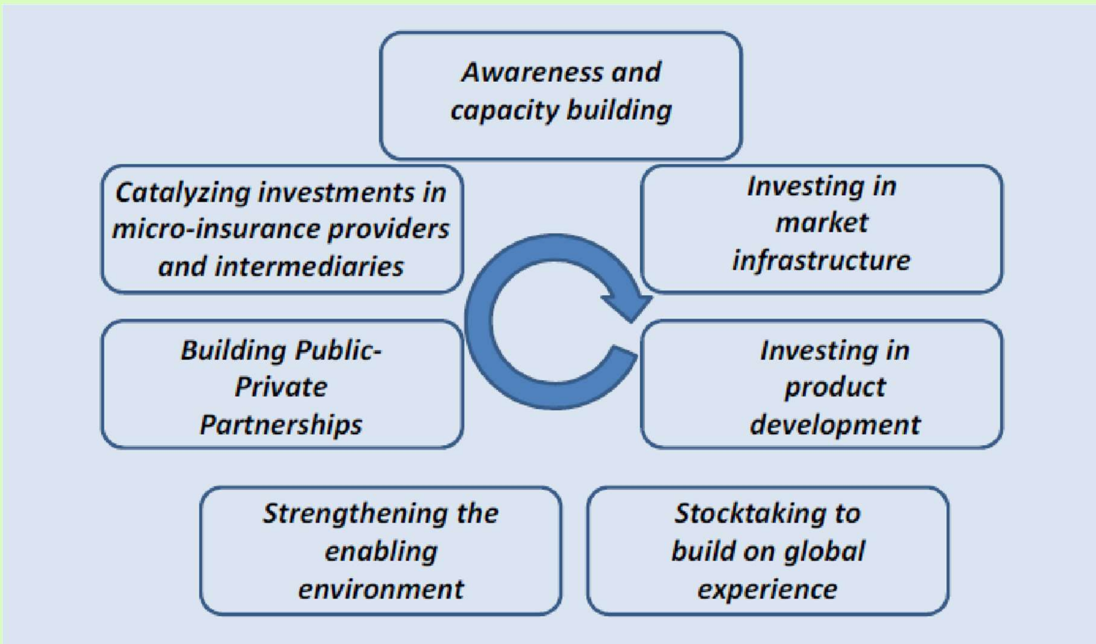
Property catastrophe risk insurance policies cover disaster-related damage to physical assets or loss of income arising from damage to a physical asset. These may take the form of household and contents insurance, or cover for commercial and industrial assets (typically as an 'All-Risks' policy). Loss of income and alternative living expenses can be covered although these covers are not as widespread. Underwriters tend to be selective in granting cover where disaster risk is high.

d) Disaster microinsurance

Microinsurance specifically targets low-income people and offers protection against specific perils in exchange for regular premium payments proportionate to the likelihood and cost of the risk involved (Churchill, 2011). The World Bank has developed a comprehensive microinsurance development strategy outlined in Box 2.4 below.

Box 2.4: The World Bank strategy for microinsurance development

The growth of micro insurance markets in developing countries face a number of key challenges which have been identified as: (i) weak distribution and service delivery channels and high transaction costs; (ii) poor product design and low value proposition from the perspective of the insured; (iii) lack of financial literacy, consumer awareness and trust in the insurance sector and similarly lack of capacity and understanding of microinsurance within insurance companies; (iv) inadequate legal, regulatory and supervisory framework ; and (v) high risks of investment in the microinsurance business line. In response to these challenges the World Bank has outlined a strategy for microinsurance development, based on seven pillars:



Strategy for Microinsurance Development, Source: World Bank Group Microinsurance Development Program, Concept Note

It is equally important to make the distinction that although at times microinsurance is loosely used to refer to general risk prevention and management techniques (e.g. savings set aside for emergency purposes, such as insurance funds), here we utilise a very narrow definition of microinsurance. Microinsurance within the context of this study involves an element of risk pooling. A simple description offered by Churchill (2011) is a situation in which 'those in a risk pool who do not suffer a loss during a particular period essentially pay for the losses experienced by others. Insurance thereby reduced vulnerability as households replace the uncertain prospect of losses with the certainty of making small, regular premium payments. This risk pooling function means that insurance is a much more complicated financial service than savings or credit'.

2.5 Who are the Potential Clients and how may they benefit?

Insurance can be used to cover risks at the macro, meso and the micro level. Below the potential benefits and limitations of catastrophe insurance are examined for various stakeholders at each of these levels.

2.5.1 Government

In the aftermath of a disaster Governments' own reserves, budget contingencies, budget reallocations and emergency loans are the most common sources of post-disaster financing. Unfortunately, these all also have limitations. Budget contingencies usually represent about 2 to 5 percent of government expenditures and are not only earmarked for natural disasters. Vietnam, for example, has experienced cases where a major cyclone hit the country late in the year in November, and the contingency budget had already been fully exhausted. This experience is one that is also familiar to many Sub-Saharan Africa countries. Beyond the opportunity cost of short-term liquidity sitting in an account, competing demands and political considerations make it virtually impossible for governments to build reserves beyond a certain level. Systematic use of budget reallocations endangers development programs that have often required years of preparation. Emergency loans may take a long time to negotiate and do not allow for immediate resource mobilisation. The amount of international aid is also uncertain and may take too long to mobilise. Insurance can therefore provide Governments with immediate access to funds after a catastrophe has occurred, easing pressure on fiscal budgets and therefore smoothing the Government's budget volatility over the long run. It can improve contingency planning as pre-determined premiums allow for a greater degree of budget certainty, and this can attract more investment to the country.

On the other hand, as seen in Table 2.1, sovereign catastrophe insurance can be costly and governments may have to pay significantly more in insurance premiums than their expected losses (Suarez & Linnerooth-Bayer 2011). Thus the use of insurance and ART remains a relatively expensive proposition for governments in developing countries such as those in Sub-Saharan Africa and their use has remained limited to specific cases (Box 2.5) Premiums are high partly due to the nature of natural hazard risks, which will hit entire communities and regions at one time. In order to face these co-variant risks insurance companies must hold large amounts of reserve capital, obtain re-insurance, and diversify their portfolios; which all add significant costs. Premiums are also expensive due to the high start up costs and transaction expenses in developing countries.

Governments also need to bear in mind that index insurance is taken out against events that may cause a loss, rather than the actual loss. These index products suffer from basis risk, which is the risk that payouts do not match losses – for example where losses are incurred, but no payout is received. Basis risk is an inherent feature of any index-linked insurance product as no index can correlate perfectly with losses incurred. For example, four storms in Haiti created considerable damage in 2008 but because most of this was due to flooding and not wind (the triggering parameter of the index based coverage) a payout was not triggered by CCRIF. For the public, the benefits from the purchase of sovereign insurance may also be mixed if funds are badly administered due to institutional weaknesses.

Instruments	Indicative Cost (multiplier)	Disbursement (months)	Amount of funds available
Donor support (relief)	0-1	1-6	Uncertain
Donor support (recovery & reconstruction)	0-2	4-9	Uncertain
Budget contingencies	1-2	0-9	Small
Reserves	1-2	0-1	Small
Budget reallocations	1-2	0-1	Small
Contingent debt facility (e.g., CAT DDO)	1-2	0-1	Medium
Domestic credit (bond issue)	1-2	3-9	Medium
External credit (e.g. emergency loans, bond issue)	1-2	3-6	Large
Parametric insurance	2 & up	1-2	Large
ART (e.g., CAT bonds, weather derivatives)	2 & up	1-2	Large
Traditional (indemnity based) insurance	2 & up	2-6	Large

Table 2.1: The cost of financial instruments
Source: Ghesquiere, F., and O. Mahul (2010). Financial Protection of the State against Natural Disasters: A Primer. World Bank Policy Research Working Paper # 5429

Table 2.1 provides indicative cost multipliers contrasted with the speed at which funds can be mobilised from each source of financing described above. The cost multiplier is defined as the ratio between the (opportunity) cost of the financial product (e.g., premium of an insurance product, expected net present value of a contingent debt facility) and the expected payout of that financial product. The multipliers are only indicative and aim to illustrate the cost comparison of the financial products. The speed at which funds can be obtained also varies greatly depending on legal and administrative processes that drive their use.

BOX 2.5: Malawi – sovereign weather derivative

For the agricultural seasons 2008/9 through 2011/12, the Government of Malawi purchased severe drought protection in the form of weather derivative contracts which provide coverage against the risk of severe drought during the critical rainfall season. The contract used by Malawi to transfer the risk is based on a weather index that incorporates the Malawi Meteorological Services Department's national maize yield assessment model which uses daily rainfall as the only varying input to predict maize yields and therefore production throughout the country.

The World Bank has played an intermediary role to assist Malawi in accessing the market. During the first three years of the program, co-financing of the premium was provided by the UK Department for International Development (DFID). In 2011/12, co-financing of the premium was supported through an IDA credit, the Malawian Agricultural Development Program Support Project.

Following a review of the project undertaken in March 2011, a number of options for the future development of the program were identified based on the Government's future priorities including: financing for more frequent, less severe events (lower layers of risk); the possibility of a disaggregated index operating on a sub-national regional basis; and the option to connect sovereign level financing directly to farmers at the micro-level (as has been done in Ethiopia using the productive safety net program).

It is notable that the Government of Malawi opted not to purchase the protection for 2012/13, a decision likely due in significant part to the lack of clarity on the pathway to implementing the future priorities listed above, all of which relate to the lack of insurance tools at the micro- and meso- levels to complement the sovereign programme.

Source: Disaster Risk Financing and Insurance in Sub-Saharan Africa: Review and Options for Consideration, World Bank. November 2012 and personal communications with World Bank staff

2.5.2 Infrastructure and Utility Companies

SSA is amongst the fastest growing and urbanising regions in the world and yet there is a vast gap in the demands being made on power, water, housing and transport and its capacity to supply these services. Weather risk from precipitation, temperature, wind and seasonal lengths further compounds the stress on the coping capacity of the infrastructure. As seen in other countries globally the exchange rate and price of crude oil[14] can add to the financial burden preventing the infrastructure to operate efficiently. An indicative measure of infrastructure spending in high weather risk countries is provided in later chapters. The Africa Infrastructure Knowledge programme reports that: 'Africa's largest infrastructure needs are in the power sector. Whether measured in generating capacity, electricity consumption, or security of supply, Africa's power infrastructure delivers only a fraction of the service found elsewhere in the developing world (Eberhard and others 2008). The 48 countries of Africa (with a combined population of 800 million) generate roughly the same amount of power as Spain (with a population of 45 million). Power consumption, which is 124 kilowatt-hours per capita per year and falling, is only 10 percent of that found elsewhere in the developing world, barely enough to power one 100-watt light-bulb per person for 3 hours a day.' The World Bank is investing in substantial multi-country hydro power-pools across the continent which can learn a lot from the Bank's own experience in South America on weather hedging in the energy sector. Such hedges can also benefit the transport, housing and water sectors equally at financial risk from weather impacts. Other than WB, other donors such as the Nordic fund, DFID-NIAF, PIDG and countries such as China are investing in Africa's infrastructure; this creates a substantial interest base for weather risk financing instruments, including insurance.

[14] Gains and losses are also possible in a short period of time from such volatility such as in Nigeria, a heavy exporter of crude oil.

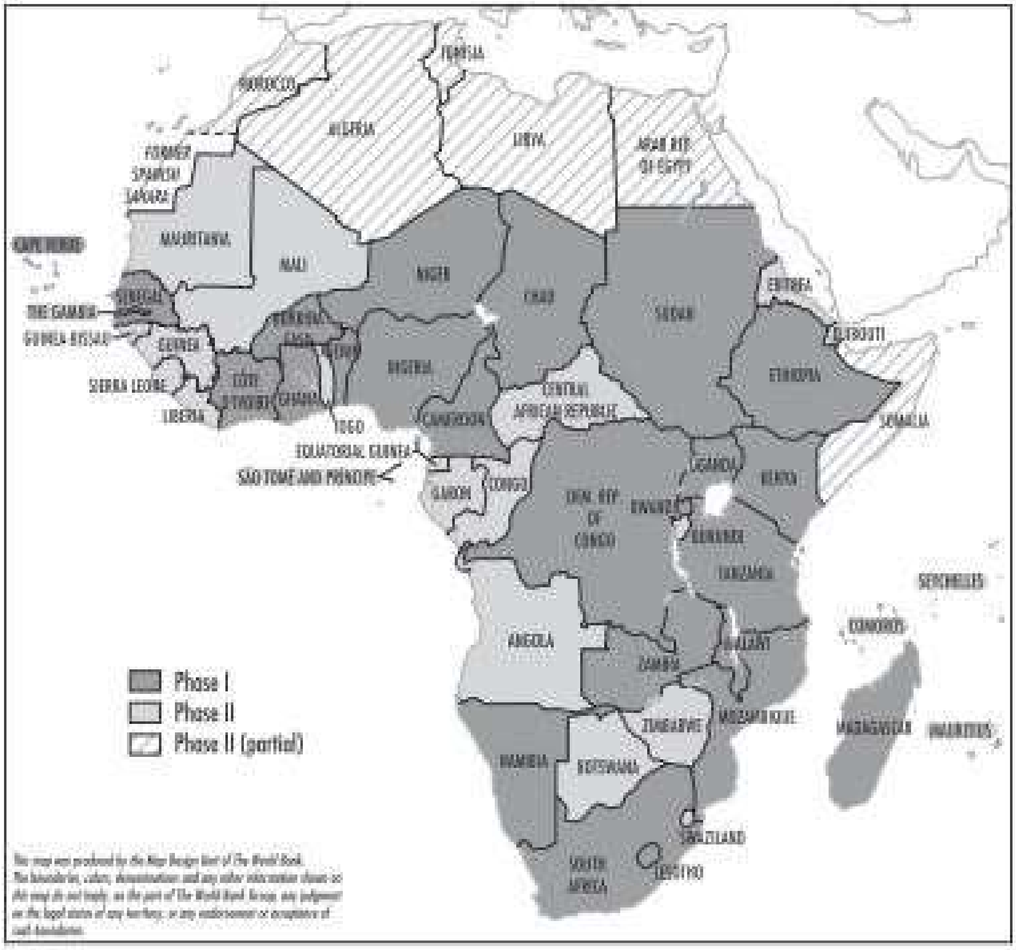


Figure 2.8: Coverage of the Africa Infrastructure country diagnostic, Source: Africa infrastructure knowledge programme

2.5.3 Lenders

Natural disasters pose two problems for lenders (Skees, Hartell and Goes, 2006). Firstly, they increase the likelihood of mass defaults and secondly, they create liquidity problems as clients draw down their savings and simultaneously demand more credit. Credit default risk is particularly costly when it has a covariant nature, as is often the case with lending portfolios in the agricultural sector. Furthermore, lending in the low-income sector is often supported by less substantial collateral than is otherwise the case, with the collateral also being impacted by catastrophic weather events.

Lenders who cannot hedge against weather risks are more likely to ration credit, or make available contracts too expensive. They may even withdraw credit entirely after a disaster. In the absence of insurance markets credit markets fail to work effectively, which in turn restricts economic growth and may increase the vulnerability of the poor.

Lenders are also in the position of having an existing risk management and pooling function, thus enabling the combination of lending and insurance to reach a broad client base and produce synergies which benefit both the lending institution and the borrower.

2.5.4 Businesses

Insurance removes risks from the balance sheets allowing higher profit and higher risk activities to be pursued. It also spreads the cost of losses and thus provides more stable long term financial results, which in turn makes businesses more creditworthy. Businesses often face additional costs after a natural disaster as they may need to repair or replace damaged property, inventory and business equipment. They will simultaneously have to continue covering fixed expenses such as rent, utilities, salaries etc. Insurance can provide businesses with much needed liquidity, increasing the likelihood that they will weather the storm and continue operating in the long run. This has positive knock on effects to companies throughout its supply chain, to its employees, and the Government's tax base.

Insurance, however, still does not guarantee a business' survival after a disaster, as customers may no longer need or want its goods and services. Also traditional property/catastrophe insurance is often not affordable for young and / or small businesses, particularly in the development context, and innovation is required to bring MSMEs in particular into the insurance marketplace.

2.5.5 Farmers

Natural hazards can wreak chaos on the agricultural sector on which 70% of the population depends for its livelihood. Many studies have found that the risk of natural disasters affects the behaviour of farmers. They tend to limit their exposure to extreme events by engaging in low risk, low yield farming and are reluctant to borrow and invest in productive assets or modern inputs such as fertiliser. Insurance can therefore make farmers more creditworthy and reduce uncertainty. In theory banks are therefore more likely to provide credit and farmers may in turn invest in high risk, high yield farming and thus increase their agricultural productivity.

To date, however, there has been little evidence that insurance has induced a shift towards higher risk/higher yield activities (see box on index based instruments in Chapter 5). Again, as with sovereign insurance, farmers may also face the problem of basis risk. A farmer may lose his entire crop to disease but not receive a payout since the insurance is only triggered by rainfall. Another factor to bear in mind is that in immature and unregulated markets, which are often found in developing countries, there is a high risk of insurer insolvency or defaults.

Furthermore, for insurance to be affordable for small holder farmers premiums either need to be subsidised, or transaction costs reduced by using index based instruments. Yet, subsidies may provide negative incentives and they are generally not recommended for any longer than the starting period (even though they are endemic in agricultural insurance in the developed world, largely for social reasons). Even with these subsidies, the upfront premium payments may still be higher than subsistence farmers are willing or able to pay. Index based instruments, as discussed, suffer from basis risk.

Commentators have also raised questions around fairness and liability. Should the poor be shouldering the (added) financial burden of insurance premiums when their exposure and vulnerability to natural hazard risks is largely due to their Government's failure to implement effective risk reduction measures? (Cohen and Sebstad, 2003) These premiums are only likely to increase as climate change creates increasingly severe and variable natural disaster risks, yet poor households in developing countries have arguably played no part in contributing towards climate change.

2.5.6 Households

Community support measures tend to be inadequate following natural disasters which affect entire communities at once. To cope with shocks and smooth their consumption, households deplete their savings, take out high interest emergency loans or sell assets and livestock. Poor families find themselves locked into a poverty cycle which is likely to affect their long term vulnerability. Insurance can therefore smooth this consumption volatility by spreading the peak downside vulnerability across a long time period

The limitations of insurance for households are similar to those outlined above for farmers.

2.5.7 Relevant World Bank Programmes and Outcomes

During the course of this project the team has interacted broadly with World Bank experts, both regional and technical, who are or have been active in the weather risk insurance space, generally in Africa but also elsewhere. These individuals and teams are drawn from a broad spectrum of Bank disciplines and vice-presidencies, and it is not always clear to an outsider exactly how these programmes interact with one another and how best-practice and lessons learned are shared. There is a substantial knowledge base in formal Bank-reviewed (and, to a lesser extent, peer reviewed) literature, although several key studies in Africa, including sovereign level disaster risk financing reviews and a comprehensive review of the socio-economic impacts of index-based insurance have not yet been fully reported (Financial Innovations for Social and Climate Resilience (FISCR) project, Benson et al. 2012). The FISCR project in particular promises significant insight into the value proposition for weather index insurance. It aims to '*establish an evidence base of experience to date with market-based risk financing instruments that aim to target poor households related to access to coverage, sustainability, poverty reduction/resilience building impacts, and value for money*.' It will be important to integrate the findings of that study, once published, into plans for future interventions in the weather insurance space across Sub-Saharan Africa.

There are three main areas where the Bank has been most active in Africa:

- Development of agricultural risk management strategies (with associated insurance components), e.g. Agriculture and Environmental Services (AES) Department work in Niger (World Bank, 2013);
- Specific technical assistance support and/or financial support (generally through the Global Index Insurance Facility managed by IFC) for index-based weather insurance initiatives (e.g. West African Economic and Monetary Union initiative with PlaNet Guarantee); and
- Technical assistance support (e.g. World Bank 2012) and product execution (e.g. Malawi weather derivative, Syroka & Nucifora, 2010) at the sovereign level.

Initiatives elsewhere in the world are also having an impact on Bank strategies within Africa:

The South and Central Europe Climate Insurance programme (now encapsulated within a private sector vehicle, Europa Re), an innovative approach to private catastrophe market development leveraging a technological and data-driven approach to lower costs and increase penetration of traditional catastrophe insurance (see Europa Re, 2012).

The Pacific Catastrophe Risk Assessment and Financing Initiative, which has concentrated on building a substantial risk assessment platform and dataset, and enhancing national capacity in sovereign risk financing, prior to piloting a parametric sovereign risk transfer product (World Bank, 2013b). This general strategy for sovereign risk financing engagement is also being followed in South Asia (e.g. Pakistan).

The focus of the development community's activities in the index-based weather insurance space has evolved over the past several years, with the World Bank at the forefront of both the testing and the documenting of experience. Index-based insurance for weather risk was initially seen in a largely positive light by donors and it received a relatively high profile in the UN-FCCC climate change negotiations (e.g. MCII, 2010). Recently, the needle has shifted as commentators have pointed to the numerous challenges surrounding the implementation of index based insurance and its true client value. Mitchell (2012) and Clarke (2012) have both been close observers of global initiatives in the insurance / climate change adaptation space, and the following key points are a merging of their views as expounded in these blog pieces:

- Insurance is not a solution in and of itself, and can (and must) only play a part in what needs to be a holistic risk management approach, whether applied at the micro-, meso- or macro level. In many cases, risk reduction is the most cost-beneficial approach to managing a substantial portion of current and future weather risk, and without risk reduction, insurance products may become increasingly unaffordable.
- Insurance does not and cannot cover all of the risks faced by low-income populations, even those highly exposed to weather risk and, potentially, climate change; in particular, indexbased weather insurance can only cover a very specific tranche of risk. End-users want certainty in benefits, and basis risk in index products represents a very substantial challenge to effective catastrophe microinsurance. An increasing focus on managing catastrophe risk at the meso level (e.g. through lenders, suppliers or other risk aggregators) reflects these concerns with basis risk and is likely to be increasingly used as the operational mode for index-based microinsurance.
- There is the lack of an evidence base quantifying the costs and benefits of catastrophe microinsurance, and that which is available is mixed in its evaluation of outcomes (although such conclusions can only be viewed as preliminary due to the generally short time periods and small sample sizes used).
- The tools used by the insurance industry for understanding, mapping and quantifying hazards and risks are critical in establishing the risk management landscape and evaluating the best tools to manage the total risk spectrum. However, these tools remain largely inaccessible to the developing world and vulnerable low-income populations in particular.
- The public sector needs to continue to play a substantial role in developing, implementing and sustaining insurance mechanisms for low-income populations in the developing world. While index-based weather insurance, particularly in agriculture, provides the possibility of substantially reducing costs (relative to the underlying risk) when compared with traditional indemnity insurance, the premium levels are still not low enough for the poor to afford them without state assistance. The mode of this support is critical to establish the correct balance between market forces and the social protection priorities of the state.

3.0 WEATHER RISK: HIGHLY VULNERABLE COUNTRIES

3.1 Introduction

Natural hazards in the form of floods, droughts and cyclones pose a real and significant threat to lives, livelihoods and economic development in Sub-Saharan Africa. In the face of higher climatic uncertainty due to climate change and an anticipated increase in the frequency of hazardous weather, the need to increase resilience to these events is pressing.

Insurance instruments represent one way to reduce the impact of hazardous weather yet these tools remain widely undeveloped in Sub-Saharan Africa. In order to bridge this gap, the World Bank seeks to initiate regional programs of support to this sector in selected priority countries.

The identification of these priority countries constitutes part of phase 1 of this project which has looked at countries *'that would most likely **benefit** and **be ready** for climate risk financing'* [15]

The assessment of which countries would most likely benefit from climate insurance has been approached through considering the climatological factors which predispose a country to floods, droughts and cyclones and then documenting recorded occurrences of these hazards and their impacts, as reported across a range of data sources.

3.2 Identification of priority countries

3.2.1 Climatological drivers of floods, droughts and cyclones in SSA

Complex interactions over the land and oceans affect the climate in Africa and produce a variety of climatic zones. Whilst increasing variability in Africa's climate is being documented (as captured in the IPCC's fourth assessment report) large scale climatological features drive much of the weather experienced in the continent and their behaviour patterns mean that some areas are more prone to floods, droughts and cyclones, as shown in figures 3.1, 3.2 and 3.3 below.

For heavy rainfall large areas of Western Africa including Nigeria, Burkina Faso and parts of East Africa including Kenya and Ethiopia are also highlighted as the most prone to rainfall events. Kenya and Nigeria appear again as the countries which are most prevalent to drought. However, as storms generally develop over the ocean the areas most prone are further south and include Madagascar and Mozambique.

[15] World Bank TOR (Consulting Services): Insurance Instruments for Africa Climate Adaptation – First Phase Assessment, January 2011

Figure 3.1: Areas of Africa climatologically prone to heavy storms rain

Figure 3.2: Areas of Africa climatologically prone to droughts

Figure 3.3: Areas of Africa climatologically prone to

3.2.2 Floods

Precipitation is caused by the forced rising of air masses. This rising can be caused by convergence[16] on both broad and local scales, synoptic depressions and their associated frontal systems and orographic features (e.g. a mountain range which pushes air up). It is also caused by convection, warm air rising and condensing as it cools. While depressions do influence Southern and Northern extremes of the continent most rainfall in Africa is linked to the Inter Tropical Convergence Zone (ITCZ), a zone of largely convective rainfall which is enhanced by high ground and by large-scale disturbances within it.

The Inter Tropical Convergence Zone (ITCZ) is a global scale area of convergence between dry, anticyclonic air masses on both poleward sides of an equatorial belt of moist air. The interface of the warm air with dry, stable air forces uplift to forms clouds and rain, which occurs both as a major seasonal feature and intense localised thunderstorms. The ITCZ's location can vary as much as 40° to 45° of latitude north or south of the equator on land, as illustrated in Figure 3.4, which shows the southerly position of the ITCZ in January and its northerly position in July.

West Africa as a whole is affected by the northward migration of the ITCZ. The position of the ITCZ varies more in West Africa than in central regions due to thermal gradients along Africa's coastline. As it moves poleward north of the Equator, higher sea surface temperatures off the coast of West Africa (Cameroon to Guinea) lead to squalls and longer periods of heavy rains in this area. When the ITCZ[17] pushes further north, it brings heavy rain from large-scale systems to the **Sahel region** (Northern Nigeria, Niger, Burkina Faso) during July, August and September. The northernmost extent of the ITCZ is highly variable, year by year, and the geographical extent and duration is critical. As this is the area's only rainy season, intense rain often falls on dry ground which can lead to flooding (whereas terrain further south receives more regular rainfall over a longer period, or even two distinct seasons in the coastal countries), and the effects of intense downfalls are less damaging.

[16] Wind movement that results in a horizontal net inflow of air into a particular region.

[17] Sometimes referred to as West African Monsoon

Eastern Africa (South Ethiopia to Central Tanzania) has two rainy seasons as the ITCZ moves northward over this region between February and May, and southward again between October and December. Since the distance covered by the ITCZ is quite large in this part of the continent, the rainy seasons are less intense than those of Western Africa as rain is distributed over a larger area. However, high ground in Ethiopia, Kenya and Rift Valley countries (e.g. Uganda, Rwanda) intensifies rainfall activity, leading to increased frequency of flood-related hazards.

Southern Africa (Zambia and Mozambique southward) lie at the extremity of the movement of the ITCZ and like Sahelian countries receive a single rainfall season, from November to February, depending on position. The presence of cold currents off the west coast of southern Africa and the high interior terrain of South Africa limits the poleward extent of the ITCZ, giving rise to arid and semi-arid conditions in Namibia, Botswana and parts of South Africa. These areas can be subject to infrequent but heavy downpours and flash floods.

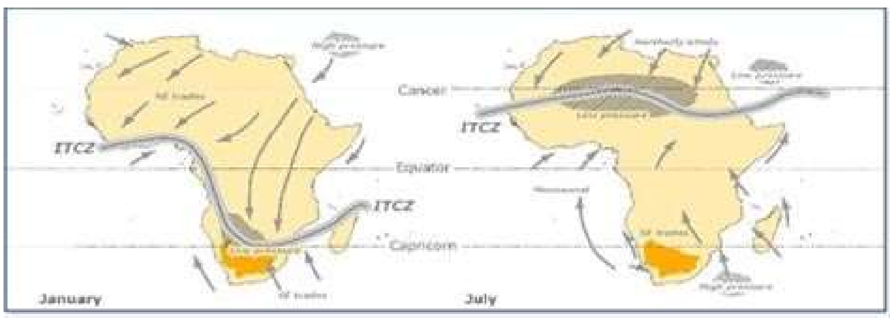


Figure 3.4: Mean position of ITCZ over Africa in January and July

Rising, rainfall-producing air masses have also been attributed to the African Easterly Jet (AEJ) and Tropical Easterly Jet (TEJ), strong easterly winds which, like the ITCZ, oscillate north and south throughout the year. Inter annual variations in the wet season have been linked to variations in the strength and latitudinal separation of these jets (Nicholson & Grist 2003).

In urban areas the impact of flooding is often more rapid and more extreme due to high population densities, poor drainage and other infrastructure, and pollution from sewage and other sources. The effect is intensified as cities grow in size and numbers without accompanying infrastructure development or early warning systems.

3.2.3 Droughts

Drought is a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage and causing adverse impacts on vegetation, animals, and/or people. Drought is a temporary aberration from normal climatic conditions and is different to aridity, in which state low precipitation is normal (e.g. in a dessert or semi-desert). However, in semi-arid areas and areas where the rainfall season is short, the extension of the dry season or lack of rainfall activity during the normal wet season will result in drought conditions, which are made more critical due to the fragility of agriculture and pastoral activity.

Droughts demonstrate a cyclical pattern of behaviour and can have a tendency for extending over many successive years. The IPCC AR4 Report notes that droughts widely affected the Sahel, the Horn of Africa and southern Africa, from the end of the 1960s to the 1990s. Pre 2000, the high frequency of droughts experienced in the **Sahel region** was probably due to the weakening of the ITCZ. As this area only receives rains once a year during a three month period, it has a very short growing season and has a high vulnerability to reduced rain from the ITCZ. Since 2000, the incidence of drought has considerably reduced. Recently, **East Africa (Somalia and Kenya)** has been affected by widespread and devastating droughts which have been caused by failure in rains over consecutive seasons.

Many studies have explored the causes behind the increased frequency of droughts in recent decades and there is considerable controversy within the scientific community about the factors (anthropogenic or natural) which have led to an apparent increased frequency of droughts in recent years. The IPCC[18] AR4 Report highlights the need for further research into understanding how possible climate regime changes in Africa will affect rainfall. It also acknowledges that complex feedback mechanisms, mainly due to deforestation/land-cover change and changes in atmospheric dust loadings that are an outcome of population pressure, have also been found to play a role in climate variability and its variability, particularly for drought persistence in the Sahel and its surrounding areas (Prospero and Lamb, 2003[19]).

Because of the uncertainties as to the behaviour and causes of drought, historic data alone may not provide adequate indications of future drought patterns in chosen pilot areas. In essence, the past does not necessarily indicate the future. Climate models therefore provide useful tools in postulating alternative scenarios as references for the development of climate-based insurance schemes designed to minimise the impacts of drought.

3.2.4 Cyclones

The tropical cyclone systems which have the greatest landfall in Africa form in the South West Indian Ocean where conditions are favourable for their formation and development from December to April. On average, about eight storms of tropical storm intensity or greater form per year. Their main occurrence falls a little after the passage of the ITCZ in coastal areas of south-east southern Africa, particularly Mozambique and Madagascar. The principal hazard features connected with cyclones are heavy rain, high winds and, in relation to particular coastal and estuarine areas, tidal surge formed by a combination of wind and low atmospheric pressure at the centre of the cyclone.

Extremely heavy rainfall is concentrated in the eye wall of the cyclone and in the associated spiral bands (a record 187cm has been recorded at Cilaos on Reunion), but the passage of a cyclone will produce an extended period of heavy rainfall, often as much as 2-3 days. Large cyclones making landfall will produce major flood incidents over extensive areas. The impacts of cyclones will also be enhanced in mountainous areas such as Madagascar as cyclone-associated rainfall can be accompanied by disastrous land-slides. When a tropical storm comes inland and decays e.g. over

[18] IPCC AR4 – Intergovernmental Panel on Climate Change Assessment Report 4 http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socioeconomic impacts. In the same year, the UN General Assembly endorsed the action by WMO and UNEP in jointly establishing the IPCC.

[19] Prospero. J., M, and Lamb.P.J. 2003: African droughts and dust transport to the Caribbean – climate change impacts. *Science 7*

Mozambique, although the strong winds and circulation can no longer be identified, heavy rainfalls can still occur.

3.3 Recorded occurrences of floods, droughts and cyclones and their impacts

In order to assess the incidence of floods, droughts and cyclones in SSA, a range of data sources have been interrogated and the data has been cross compared.

Accurately mapping flood, drought and where cyclone occurrence and impacts are greatest is a complex task due to the wide range of data sources which are available and the discrepancies and inconsistencies in the way the data on these hazards is captured and reported by different organisations. As Purkayastha, Clarke and Murray (2011) recognise, this has 'produced a voluminous yet inconsistent evidence base for policy-makers and practitioners in the field to draw upon and runs the risk of undue emphasis on the output from a single source.'[6]

For the purposes of identifying priority countries for this project, disaster databases were chosen because of their ability to provide reasonable levels of consistency in the methods and type of data collected on floods, droughts and cyclone across the continent.

As shortcomings have been identified with disaster databases in general (such as reporting inconsistencies and biases) a number were consulted for this exercise, as described in Table 3.1 below.

EM-DAT – EM DAT (EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be, Université Catholique de Louvain, Brussels (Belgium). *Appendix 2*

This dataset has similar data on all three disaster types of interest, and appears to be the most cited in academic work. The database contains data on the occurrence and effects of over 18,000 mass disasters[7] in the world from 1900 to present.

EM-DAT was found to provide most comprehensive source of data on the frequency and impacts of these hazards across Sub-Saharan Africa. Where possible EM-DAT data was cross compared with other sources including:

- Media reports
- The Dartmouth Flood Observatory
- Glide
- Food and Agriculture Organization of the United Nations list of Reported Drought Occurrences in Africa 1910 – 2006 and
- The IBTrACS website

UN-ISDR/GAR –*Appendix 3*

This provides an overview of national efforts to reduce disaster risk, and contributes to achieving the Hyogo Framework of Action (HFA) by monitoring risk patterns and progress in disaster risk reduction. It provides guidance and suggestions to governments and non-governmental actors on how they can disaster risks can be reduced.

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[6] Purkayastha, I.K, Clarke. M and Murray. V 2011 Dealing with disaster databases – what can we learn from heath and systematic reviews. *PloS 3*

[7] EM-DAT defines natural 'disasters' which as events in which

- Ten (10) or more people reported killed
- One hundred (100) or more people reported affected.
- There is a declaration of a state of emergency.
- Creates a call for international assistance.

There are two reports: GAR 2009 provides an analysis of global disaster risk (Chapter 2), including a case study of the Southern Mozambique drought in 1981, and includes useful comparative graphics by risk and by country. Countries included in these graphics are highlighted in the vulnerability table in Section 3.3.1.

GAR 2011 updates the global risk analysis (Chapter 2) and adds a web-based data portal and an HFA progress viewer tool. It includes a special focus on drought risk (Chapter 3), and drought impacts data for one SSA country, Mozambique 1970-2009 in graphical and tabular formats. Other information is mainly in report format, and was checked for value added to GAR 2009. **ReliefWeb -** Appendix 4

Since 1996, ReliefWeb has been a leading source for reliable humanitarian information on global crises and disasters. ReliefWeb is a specialised digital service of the United Nations Office for the Coordination of Humanitarian Affairs (OCHA). It has three main functions:

- To collect updates and analysis from over 4,000 global sources
- To curate the most relevant content – country and disaster updates and maps
- To provide country overviews and disaster updates, create original maps and infographics to illustrate and explain crises.

The main source of data is in the form of OCHA reports for individual events which have been fully or partially captured by EM-DAT. Report coverage varies from individual events to regional impacts data. There is a bias towards flood events and countries affected are highlighted in the vulnerability table in Section 3.3.1. The reporting of drought and cyclone hazard is limited.

GFDRR – *Appendix 5*

Established in 2006, the Global Facility for Disaster Reduction and Recovery (GFDRR) is a partnership of 41 countries and 8 international organizations committed to helping developing countries reduce their vulnerability to natural hazards and adapt to climate change. The partnership's mission is to mainstream disaster risk reduction (DRR) and climate change adaptation (CCA) in country development strategies by supporting a country-led and managed implementation of the Hyogo Framework for Action (HFA). The GFDRR includes a number of different initiatives including Disaster Risk Financing & Insurance, and the strengthening of weather and climate information and decision support systems (WCIDS).

Under the World Bank's Climate Change Knowledge Portal (CCKP), country profiles of climate risk & adaptation are being developed to provide real time access to basic climate information at multiple levels of detail. The profiles integrate data from the World Bank, GFDRR, and Climate Investment Fund (CIF). Of the current 48 profiles, 17 countries with flood, drought and cyclone hazards in their top two natural hazards have been added to the vulnerability table in Sections 3.3.1.

Africa Risk View – *Appendix 6*

Africa Risk View (ARV) is being developed to combine operational rainfall-based early warning models on agricultural drought in Africa with data on vulnerable populations to form a standardized approach for estimating food insecurity response costs across the continent. This information is critical to financial preparedness for drought and providing the basic infrastructure needed to establish and manage a parametric risk pool and trigger disbursements. It quantifies risk in dollar terms so that the risk can be managed using parametric, market-based approaches. It is designed to be adapted and customized to work within national frameworks, strengthening existing systems and allowing governments and their partners to define their own risk management strategy and risk pool participation. Access to ARV is limited for external organisations, hence excluded from the vulnerability analysis, but promises to provide a useful predictive service in the future.

Table 3.1: Disaster databases used to obtain information on the occurrence and impacts of floods, droughts and cyclones in SSA

The databases were analysed to provide information on the occurrence of the hazards specified and their impacts in terms of numbers of deaths, numbers of people affected and the economic cost. These impacts were selected because they were most consistently reported across the different sources but also because they were felt to provide an initial indication of vulnerability.

Richer post-event information about the occurrence, impacts, characteristics and thresholds of floods, droughts and storms may be available at a country level from the government sector mandated to collect these data (e.g. in Rwanda, the Ministry of Disaster Management and Refugee Affairs) and through the CRED database[20]. It is recommended these data are obtained and assessed as they could provide insurance firms with a deeper understanding of the nature of hazards and their effects at a country level. This type of data could also be used where insurance tools are being developed to reduce urban flood risk, as disaster databases do not tend to capture hazard information at a city-level.

A database[21] (Screen shot in Table 3.3 and provided as a separate document) pulling together information from the databases consulted has been compiled. This shows the occurrence of floods, droughts and cyclones and associated impacts (as specified above) for each SubSaharan African country. EM-DAT is the only database to provide data consistently across all SSA countries and therefore these have been compiled in spreadsheet on frequency of hazards and impacts. The GAR and GFDRR databases do not provide information in a directly comparable format and have different levels of detail for each country. Because actual impacts figures were not consistently available from these sources, vulnerable countries have been flagged and counted to indicate that a risk of floods, droughts or cyclones was identified.

3.3.1 Assessing vulnerability

Whilst numerous, definitions of vulnerability are broadly consistent in defining it as susceptibility to a shock or hazard. The factors affecting this vulnerability can relate to the community, asset or system's

[20] Centre for Research on the Epidemiology of Disasters. Provides high level view on disease and health problems post disasters, if relevant to tools. Quality of data is variable.

[21] This has been provided as a separate document

characteristics and circumstances but can also include national, regional and local capacities and institutional contexts that allow coping and adaptation.

Diversity in environmental, political, social and cultural values mean there are multiple ways of measuring vulnerability (Government Office for Science, 2012). Brookes et al (2004) identified over 46 variables representing generic vulnerability alone including education, technological capacity and governance. In the absence of a standardised methodology to measure vulnerability, and consistent data from all countries on all identified vulnerability indicators, a detailed assessment of vulnerability across all SSA countries was beyond the scope of this study.

However, in order to enhance the initial vulnerability indicators which were taken from the impacts of recorded floods, droughts and cyclones, an aggregated socio-economic vulnerability score has also been entered for all SSA countries (see table 3.2 and figure 3.5). This was compiled by interrogating data from a range of sources to give indicators of adaptive capacity (socio demographics, livelihoods, social networks and institution development) and sensitivity
(health and food) to provide a high/medium/low ranking of socio-economic vulnerability (Appendix 7).

Vulnerability Category	Countries	Aggregate Vulnerability Score
High Social & Economic Vulnerability	Somalia	1.000
	Chad	0.872
	Congo	0.861
	Niger	0.785
	Angola	0.763
	Central African Republic	0.746
	Mozambique	0.724
	Sudan	0.722
	Ethiopia	0.709
	Kenya	0.699
	Madagascar	0.683
	Mali	0.679
	Uganda	0.672
	Guinea	0.672
	Mauritania	0.653
	Burundi	0.647
	Zimbabwe	0.639
Medium Social & Economic Vulnerability	Nigeria	0.621
	Côte d'Ivoire	0.620
	Sierra Leone	0.615
	Guinea-Bissau	0.608
	Eritrea	0.606
	Congo (Democratic Republic of the)	0.601
	Zambia	0.580
	South Sudan	0.566

	Cameroon	0.556
	Liberia	0.548
	Burkina Faso	0.537
	Tanzania (United Republic of)	0.510
	Equatorial Guinea	0.490
	Senegal	0.484
	Sao Tome and Principe	0.481
	Togo	0.475
	Djibouti	0.470
	Benin	0.466
Low Social & Economic Vulnerability	South Africa	0.463
	Swaziland	0.454
	Lesotho	0.448
	Namibia	0.436
	Malawi	0.412
	Gabon	0.392
	Algeria	0.351
	Rwanda	0.318
	Gambia	0.297
	Morocco	0.295
	Egypt	0.287
	Libyan Arab Jamahiriya	0.282
	Ghana	0.260
	Cape Verde	0.240
	Tunisia	0.215
	Botswana	0.184
	Seychelles	0.162
	Mauritius	0.000

Table 3.2: Aggregate social and economic vulnerability score and country clusters, Africa[22]

[22] Source: Mazumdar and Kalra (2012)

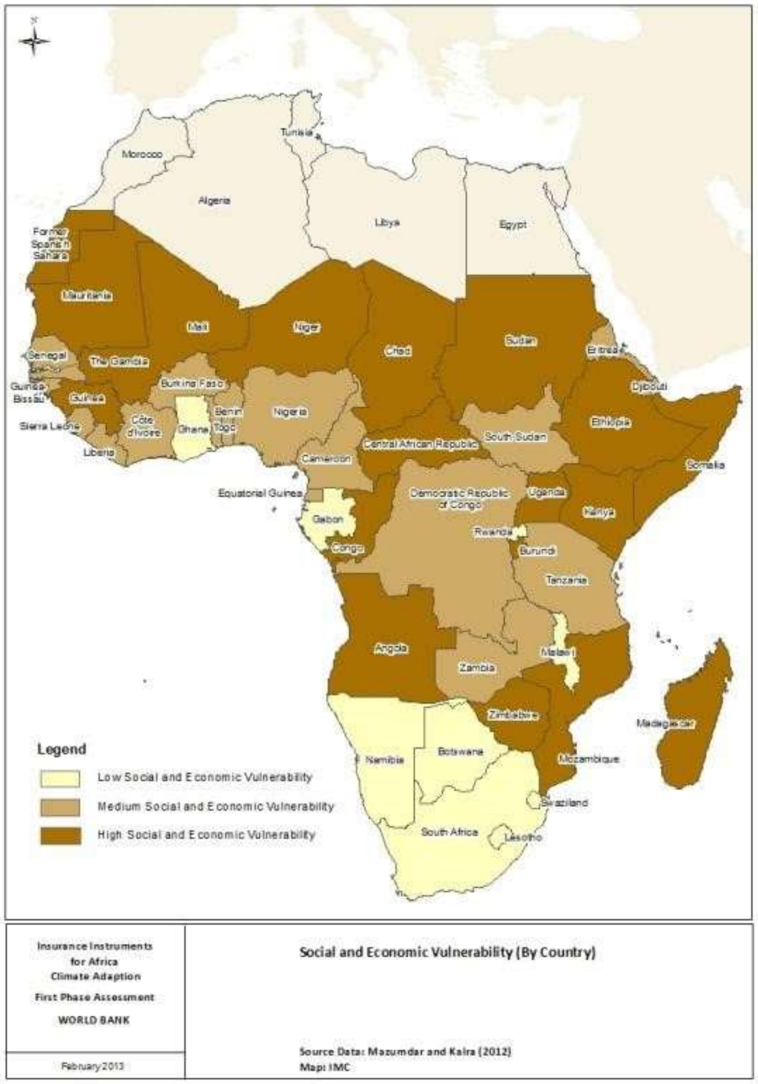

Figure 3.5: Socio-economic vulnerability ranking of SSA countries, Source: IMC

3.4 Ranking of countries by weather risk and hazard impacts data

Historic data for the impact of floods, droughts and cyclones, their impacts and socio-economic vulnerability were collated in a spreadsheet Table 3.3

The first three columns refer to climatological disposition to flood drought and cyclone hazards based on African climatology discussed in section 3.2. Countries with a high climatological vulnerability to each hazard are marked grey. For example the East African countries of Ethiopia, Kenya, Tanzania & Uganda, and the West African countries of Nigeria, Niger, and Burkina Faso are marked as pre-disposed to flooding from heavy rainfall. Kenya, Burkina Faso, Niger, Nigeria and Somalia are marked as predisposed to drought. Mozambique, Madagascar, and Reunion are marked predisposed to cyclones.

The key quantitative source of data was EM-DAT for the period 1959-2011 which records the number of years in which events occurred, the number of people affected, the number of deaths, and the damages in $US.

In terms of the 'frequency' or number of events, Ethiopia (50) recorded most floods in the period, followed by Kenya (41), Nigeria (39), Tanzania (34) and Somalia (33). Ethiopia also recorded the highest number of droughts (14), followed by Kenya, Mozambique and Somalia (all 12). Madagascar recorded the highest number of cyclones (45), followed by South Africa (24), Mozambique and Mauritius (18). Refer Discussion Report section 3.1.4.

In terms of the number of years in which events occurred, Ethiopia and Kenya recorded floods in 24 years, followed by Somalia (21 years), Malawi and Mozambique (both 20 years). Ethiopia recorded droughts in 14 years followed by Kenya and Somalia (both 12 years), Mauritania and Burkina Faso (both 10 years). Madagascar recorded cyclones in 29 years, followed by Mozambique, Mauritius and South Africa (all 16 years).

The number of years in which events occurred was used in preference to the number of events recorded for the vulnerability analysis. This was decided upon as the number of years in which events occur indicates a stronger predisposition to the climate rather than multiple events in one year which could be caused by climate variability.

In terms of flooding, the countries reporting total affected were Mozambique (9m), Sudan (6m), Zambia (5m), Ghana (3.6m), Nigeria (3.2m) and Benin (3.1 m). Note that the number affected and the total affected are separate and different in the database and affects their rank order. We have used the number affected for the purposes of this study. Those reporting most deaths were Somalia (2800), Ethiopia and Mozambique (both 2000), and South Africa (1200). The countries reporting greatest economic impacts were South Africa ($US 1400m), Mozambique ($US 1,000m), Sudan ($US 551m) and Zimbabwe ($US 276m).

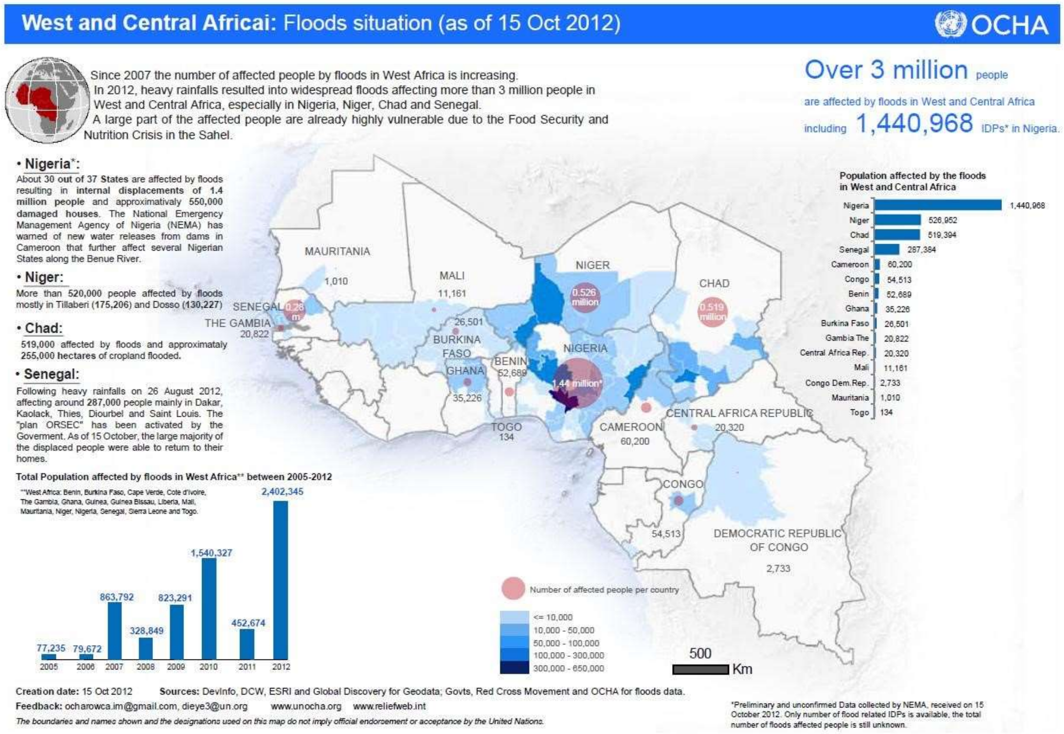

Figure 3.6 West and Central Africa Floods, Source: United Nations Organisation for the Co-ordination of Humanitarian Affairs (OCHA) report on West African Floods 2012

In terms of droughts, the countries reporting the greatest number affected were Ethiopia (66m), Kenya (43m), Sudan (27m), Niger (23m) and Malawi (20m). Ethiopia (400,000) and Sudan (150,000) also reported the largest numbers of deaths, followed by Mozambique (100,000). South Africa reported the greatest economic damages ($US 1,000m), followed by Senegal ($US 374m), Mauritius ($US 175m), and Ethiopia ($US 93m).

Madagascar (9.5m) reported the greatest number affected by cyclones, followed by Mozambique (3.7m) and Mauritius (1m). Madagascar (2400) also reported the highest death toll, followed by Mozambique (650), Comoros (560) and South Africa (270)), and the greatest economic impacts ($US 1,977m), followed by South Africa ($US764m) and Mauritius ($US 626m). Note that Madagascar reported over a 29 year period, significantly greater than Mozambique and Mauritius (both 16 years).

The EM-DAT data are based on voluntary reporting by countries using a data-card survey system, and therefore reflects the cooperation and effectiveness of the participants. It includes data for different reporting periods, with a bias towards recently improved reporting. Supporting evidence was therefore sought from other sources including UNISDR Global Assessment Reports (GAR) 2009 and 2011, the Global Facility for Disaster Reporting and Recovery (GFDRR), and Africa ReliefWeb. Where significant references or reports were found, these were flagged in separate columns. This added confidence to the analysis, but was not truly independent because the EM-DAT database includes data from these sources. Climate Risk and Adaptation Profiles were identified for 17 African countries on the World Bank's Climate Change Knowledge Portal. These profiles, prepared jointly by the World Bank, GFDRR and the Climate Investment Fund (CIF) provided comparative figures by hazard, and those countries reporting floods, droughts and hazards as the greatest risk in the profiles were flagged in a separate column.

The most vulnerable countries in each of the above categories were flagged grey. The number of flagged countries, typically top ten or top eleven varies slightly to improve representativeness over a rigid threshold based system. The exact criteria are listed in Appendix 8 (reproduced below in Table 3.3). The sum of the flagged cells therefore provides a simple indicator of hazard vulnerability of countries which reported the highest frequency (number of years) of hazards, the number of people affected the number of deaths, the most significant impacts and the highest socio-economic vulnerability scores. However they are based on imperfect reporting and other anomalies and should be considered alongside best available information on individual countries.

Additional columns were added for in country capacity for being able to support an insurance instrument or more generally 'climate risk financing' and the top-ten countries considered to be most ready, or with most potential, were flagged grey. The criteria considered for capacity included the following.

- The availability of hydro-meteorological data is considered necessary to support planned insurance instruments. Surface observations from GTS were used here although the availability of satellite precipitation and model data may also be relevant.
- The readiness of National Hydrological and Meteorological Institutions to support the provision of data.
- The availability and quality of seasonal forecasts, considered beneficial to assess seasonal financial risk.
- Governance, which would need to be mature enough to support sustainable financial and technical institutional arrangements.
- Details of how the ranking exercise was conducted can be found in Appendix 7.

The number of flagged cells were then counted to provide an overall combined vulnerability and capacity score by country [see Screenshot Table 3.5 below].The results of this combined ranking provide a list of priority countries which are given in Chapter 4 [Section 4.11].

Country	CLIMATOLOGICAL PREDISPOSITION			Databases - FLOODING							Databases - DROUGHT							Databases - CYCLONE						
	Floods	Droughts	Cyclones	EMDAT No. of Years	EMDAT No. Affected	EMDAT Deaths	EM-DAT US$ damages	UNISDR GAR2009 & 2011	ReliefWeb	GFDRR CCKP	EMDAT No. of Years	EMDAT No. Affected	EMDAT Deaths	EM-DAT US$ damages	UNISDR GAR2009 & 2011	ReliefWeb	GFDRR CCKP	EMDAT No. of Events	EMDAT No. Affected	EMDAT Deaths	EM-DAT US$ damages	UNISDR	ReliefWeb	GFDRR CCKP
Angola				13	1,084,787	483	10,000				6	2,610,000	58	0										
Benin				16	2,661,633	179	8315				2	2,215,000	0	651										
Botswana				7	132892	31	5050				6	1,344,900	0	3000										
Burkina Faso				12	485126	127	150,176				10	8,413,290	0	0										
Burundi				11	35240	48	0				6	3,062,500	126	0										
Cameroon				10	25500	99	0				4	586,900	0	1500										
Cape Verde				1	0	3	0				5	40,000	0	0				2	7,222	32	3,000			
Central African republic				13	61477	16	0				1	0	0	0										
Chad				12	724761	281	1000				7	4,756,000	0	83,000										
Comoros				1	2500	2	0				1	0	0	0				4	115,052	59	42,804			
Congo				7	101500	9	59				1	0	0	0										
Congo, Dem Rep (Zaire)																		1	22,500	17	-			
Cote d'Ivoire				5	15875	52	0				1	0	0	0										
Djibouti				7	655,500	231	5,719				9	1,188,008	0	0										
Equatorial Guinea																								
Eritrea				2	7000	0	0				3	5,600,000	0	0										
Ethiopia				24	2,188,219	1,976	17,020				14	65,941,879	402,367	92,600										
Gabon				1	10,000	0	0				3	12,512,000	0	100										
Ghana				12	3,621,924	404	108,200																	
Guinea				9	361,314	19	0				2	0	12	0				2	5,425	1	-			
Guinea Bissau				4	56,792	5	0				4	132,000	0	0										
Kenya				20	2,568,944	1,123	22,388				12	43,450,000	196	1500										
Lesotho				4	185,000	66	0				6	2,524,500	0	1000										
Liberia				5	38,070	14	0				1	0	0	0										
Madagascar				5	159,711	52	150,000				6	3,515,290	200	0				48	9,509,914	2,484	1,977,301			
Malawi				20	1,710,652	585	32,489				6	19,678,702	500	0				1	6,000	-	-			
Mali				15	154,905	87	0				9	6,397,000	0	0										

Mauritania				12	121,078	45	0				10	7,398,907	0	59,500										
Mauritius											1	0	0	175,000										
																		17	1,029,263	28	626,373			
Mozambique				20	8,988,057	1,937	937,600				12	17,757,500	100,068	50,000				16	3,684,158	652	113,550			
Namibia				9	1,084,300	264	20,490				6	783,200	0	51,000										
Niger				14	569,766	149	11,200				9	23,623,058	0	0										
Nigeria				16	2,329,130	1,014	121,422				1	3,000,000	0	71,103										
Reunion																		9	21,051	228	169,000			
Rwanda																								
				8	1,964,011	173	9				6	4,156,545	237	0										
Sao Tome &											1	93,000	0	0										
Principe											7	8,399,000	0	374,800										
Senegal				17	945,844	53	44,435																	
Seychelles				1	1,125	5	1,700											1	6,800	-	-			
Sierra Leone				7	221,189	166	0																	
Somalia				21	1,862,950	2,824	20				12	10,183,500	19,673	0				1	-	30	-			
South Africa				24	409,216	1,214	1,421,029				8	17,475,000	0	1,000,000				2	501,350	64	92,000			
South Sudan																								
St Helena																								
Sudan																								
				19	4,559,602	738	551,200				8	27,510,000	150,000	0										
Swaziland				2	274,500	0	50				5	1,630,000	500	1739				1	632,500	53	54,152			
Tanzania,				24	891,795	695	7,790				10	12,737,483	0	0				1	2,500	4				
Rep of																								
The Gambia				7	84,769	68	0				5	830,000	0	700										
Togo				9	501,570	72	0				3	550,000	0											
Uganda				10	711,785	255	1,071				9	4,975,000	194	500										
														1800										
Western				13	212,070	203	0				2	800,000	0	0										
Sahara				13	5,146,195	71	20,900				5	4,173,204	0	0										
Zambia																								
Zimbabwe				7	265,820	148	276,500				6	14,835,000	0	51,000	2	8	1,200			0.639	1	2	2	

TABLE 3.3 Screenshot of database for the ranking of priority countries

Country	FLOODS	Country	DROUGHTS	Country	CYCLONES
Mozambique	High	Ethiopia	High	Mozambique	High
Nigeria	High	Mozambique	High	Madagascar	High
Sudan	High	Kenya	High	Reunion	High
Ethiopia	High	Niger	High	South Africa	High
Kenya	High	Sudan	High	Mauritius	High
Benin	High	Burkina Faso	High	Cape Verde	High
Burkina Faso	High	Somalia	High	Comoros	High
Malawi	High	Nigeria	Medium	Swaziland	Medium
Senegal	High	Malawi	Medium	Somalia	Medium
Somalia	High	Senegal	Medium	Zimbabwe	Medium
Chad	Medium	Chad	Medium	Congo, Dem Rep (Zaire)	Medium
Ghana	Medium	Ghana	Medium	Ethiopia	Medium
Niger	Medium	Mali	Medium	Kenya	Medium
South Africa	Medium	Mauritania	Medium	Niger	Medium
Tanzania, Rep of	Medium	South Africa	Medium	Sudan	Medium
Angola	Medium	Tanzania, Rep of	Medium	Chad	Medium
Central African republic	Medium	Congo	Medium	Angola	Medium
Congo	Medium	Uganda	Medium	Central African republic	Medium
Madagascar	Medium	Djibouti	Medium	Seychelles	Medium
Rwanda	Medium	Zimbabwe	Medium	Guinea Bissau	Medium
Togo	Medium	Angola	Medium	Burkina Faso	Low
Uganda	Medium	Central African republic	Medium	Nigeria	Low
Cameroon	Medium	Madagascar	Medium	Malawi	Low
Congo, Dem Rep (Zaire)	Medium	Rwanda	Medium	Senegal	Low
Djibouti	Medium	Togo	Medium	Ghana	Low
Mali	Medium	Congo, Dem Rep (Zaire)	Medium	Mali	Low
Mauritania	Medium	Mauritius	Medium	Mauritania	Low
Mauritius	Medium	The Gambia	Medium	Tanzania, Rep of	Low
The Gambia	Medium	Cote d'Ivoire	Medium	Congo	Low
Zambia	Medium	Namibia	Medium	Uganda	Low
Zimbabwe	Medium	Seychelles	Medium	Djibouti	Low

Botswana	Low	Sierra Leone	Medium	Rwanda	Low
Burundi	Low	Swaziland	Medium	Togo	Low
Cape Verde	Low	Benin	Low	The Gambia	Low
Comoros	Low	Cameroon	Low	Cote d'Ivoire	Low
Cote d'Ivoire	Low	Zambia	Low	Namibia	Low
Equatorial Guinea	Low	Botswana	Low	Sierra Leone	Low
Eritrea	Low	Burundi	Low	Benin	Low
Gabon	Low	Cape Verde	Low	Cameroon	Low
Guinea	Low	Comoros	Low	Zambia	Low
Guinea Bissau	Low	Equatorial Guinea	Low	Botswana	Low
Lesotho	Low	Eritrea	Low	Burundi	Low
Liberia	Low	Gabon	Low	Equatorial Guinea	Low
Namibia	Low	Guinea	Low	Eritrea	Low
Reunion	Low	Guinea Bissau	Low	Gabon	Low
Sao Tome & Principe	Low	Lesotho	Low	Guinea	Low
Seychelles	Low	Liberia	Low	Lesotho	Low
Sierra Leone	Low	Reunion	Low	Liberia	Low
South Sudan	Low	Sao Tome & Principe	Low	Sao Tome & Principe	Low
St Helena	Low	South Sudan	Low	South Sudan	Low
Swaziland	Low	St Helena	Low	St Helena	Low
Western Sahara	Low	Western Sahara	Low	Western Sahara	Low

Table 3.4: Countries with a high/medium/low vulnerability to floods, droughts and cyclones
Legend: Red = high vulnerability, orange = medium vulnerability and green = low vulnerability

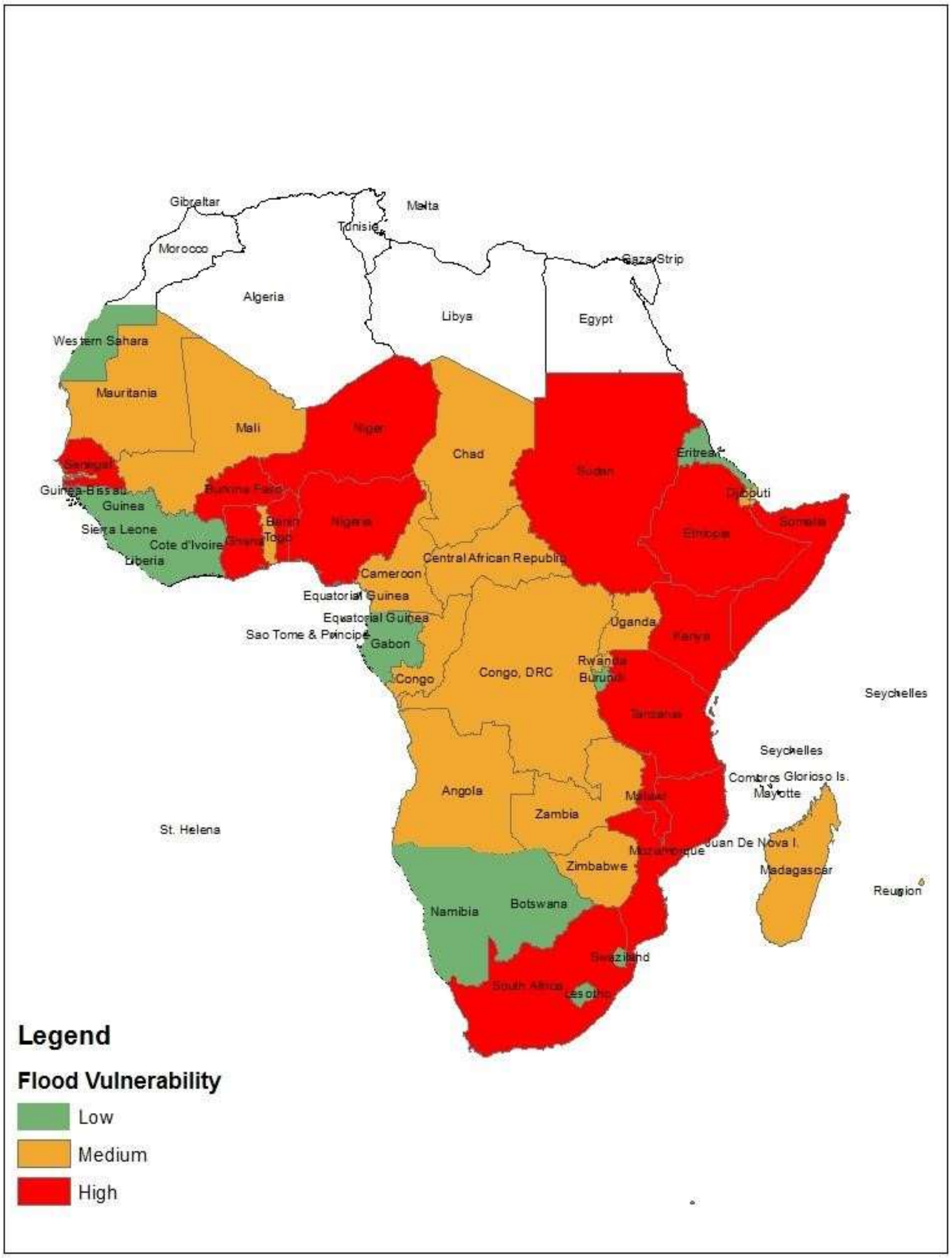

Fig 3.7: Vulnerability of Sub-Saharan African countries to floods, Source: Met Office

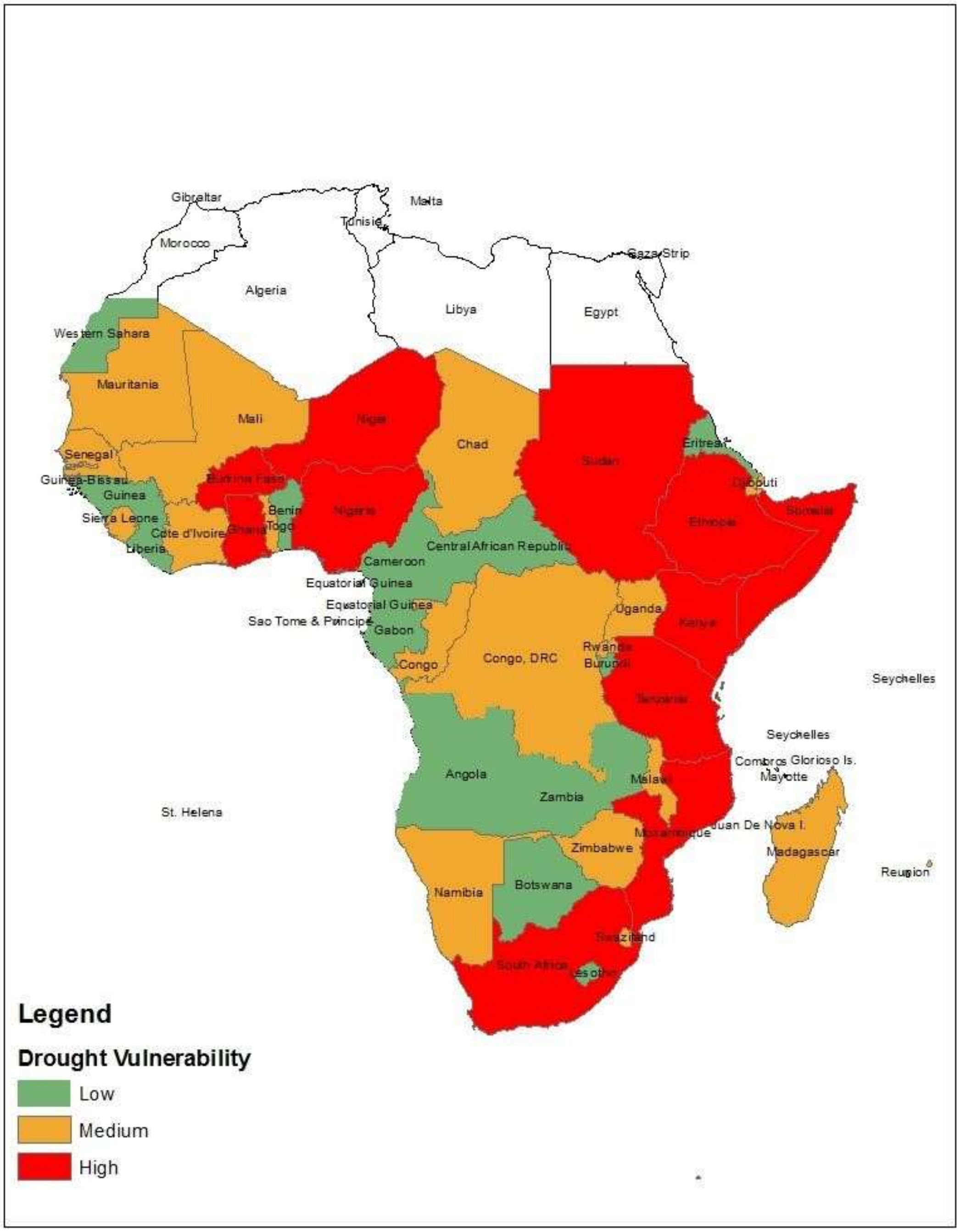

Fig 3.8: Vulnerability of Sub-Saharan African countries to Droughts, Source: Met Office

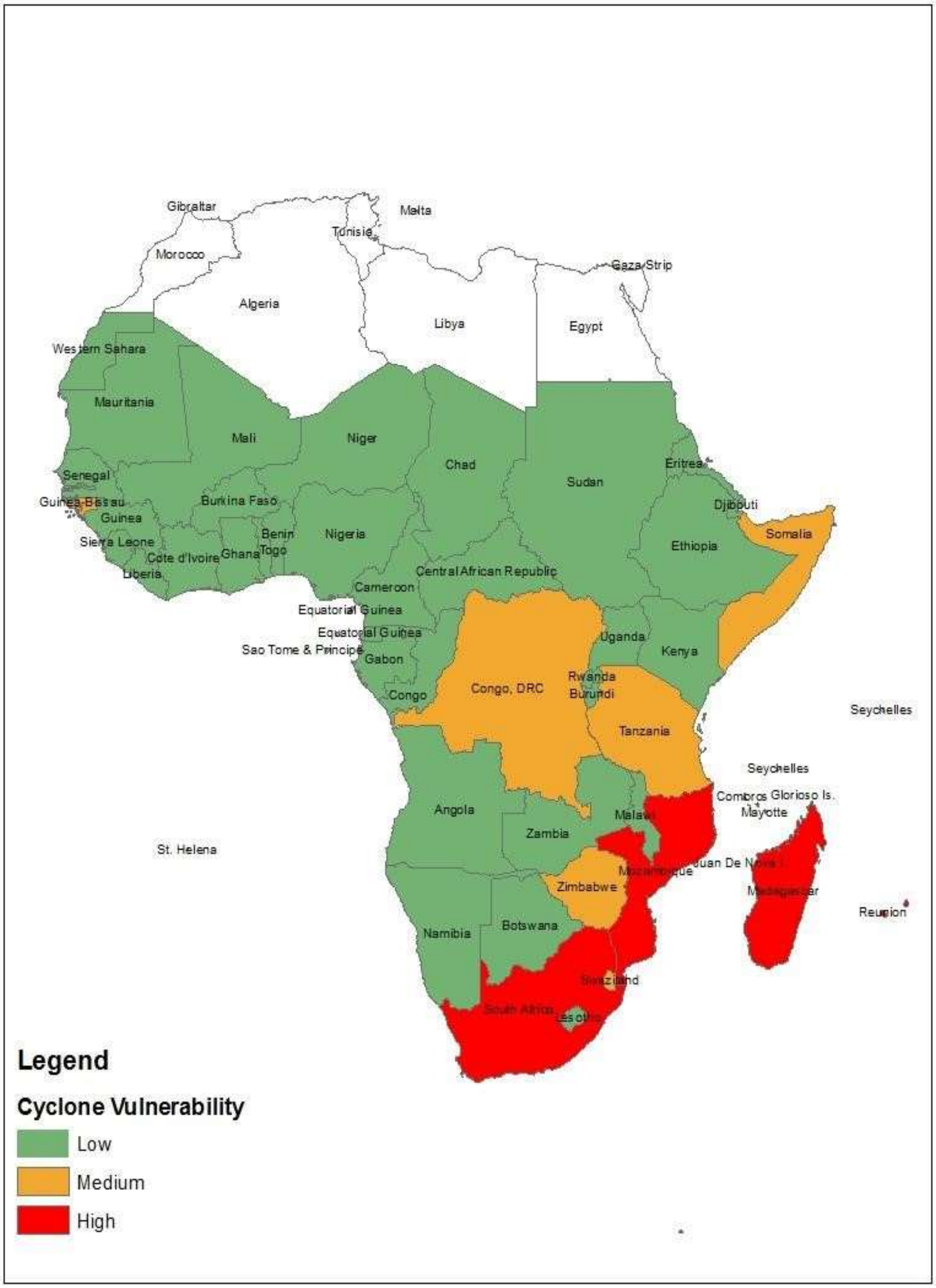

Fig 3.9: Vulnerability of Sub-Saharan African countries to cyclones , Source: Met Office

Combined vulnerability	Readiness for climate risk financing	Combined vulnerabilty and readiness factors

Entries Flooding	Entries Droughts	Entries Cyclones	Rank by GTS station density	NM(H)S	Seasonal Forecasting skill (West African and East African RCOF regions)	Governance	Combined Entries flooding	Combined Entries droughts	Combined Entries cyclones
2	1	1	49				2	1	1
4	0	0	18				4	0	0
0	0	0	33				0	0	0
4	4	0	30				5	5	0
0	0	0	13				0	0	0
1	0	0	25				1	0	0
0	0	4	50				0	0	5
2	1	1	34				2	1	1
3	3	1	46				3	3	1
0	0	4	3				0	0	5
2	2	0	29				2	2	0
1	1	2	44				1	1	2
0	1	0	24				0	2	0
1	2	0	20				1	2	0
0	0	0	51				0	0	0
0	0	0	32				0	0	0
6	7	1	41				8	9	0
0	0	0	19				0	0	0
3	3	0	12				5	5	0
0	0	0	22				0	0	0
0	0	1	10				0	0	2
6	5	1	28				8	7	0
0	0	0	35				0	0	0
0	0	0	31				0	0	0

2	1	7	26				2	1	7
4	3	0	8				5	4	0
1	3	0	40				1	3	0
1	3	0	42				1	3	0
1	1	4	5				3	3	6
7	5	8	36				7	5	8
0	1	0	37				0	2	0
3	5	1	45				4	6	2
7	3	0	48				9	5	0
0	0	5	7				0	0	6
2	1	0	27				2	1	0
0	0	0	6				0	0	0
4	3	0	16				4	3	0
0	1	1					0	2	2
0	1	0	14				0	1	0
4	4	2	39				4	4	2
3	2	4	15				5	4	6
0	0	0	2				0	0	0
0	0	0	1				0	0	0
7	4	1	43				7	4	1
0	1	3	17				0	1	3
3	2	0	38				5	4	0
1	1	0	4				3	3	0
2	1	0	9				3	2	0
2	2	0	23				2	2	0
0	0	0	47				0	0	0
1	0	0	21				1	0	0

1	2	2	11				1	2	2

Table 3.5: Screen shot of vulnerability database including capacity at the national level

3.5 Conclusions

In this chapter the following countries have been identified as being vulnerable to weather risks:

Floods: Nigeria, Kenya and Ethiopia
Droughts: Ethiopia, Kenya, Niger and Mozambique
Cyclones: Mozambique and Madagascar

Chapter 4 provides more detail on the shortlisting of the priority countries, including data availability in SSA which is required for the development of insurance markets.

4.0 WEATHER DATA REQUIREMENTS OF THE INSURANCE MARKET AND DATA AVAILABILITY IN SSA

4.1 Introduction

The types of insurance instruments, which may be appropriate for climate risk financing in Sub Saharan Africa (SSA), are discussed in Chapter 5 and their data requirements can be found in Table 5.1. Whilst some tools require various types of data, the need for detailed historic climatological records underpins the majority. The historic data record is used either to create the index and pricing, or for indemnity insurance, to seed the catastrophe risk models (see Box 4.1) required to evaluate the risk. For index-based tools, a period of records for 10 years or more is usually required.

When an index tool is used, evidence that the weather specified in the claim actually occurred is also needed in order to trigger a pay-out. This chapter explains the methods by which some of these weather data and climate patterns can be observed and derived. Regularly recorded weather data relating to the area in question therefore needs to be available and made accessible to the insurance company operating the tool. Whilst indemnity insurance claims are usually settled based on an actual assessment of loss, weather data may be required for a claim pay-out where weather perils are covered by the policy.

BOX 4.1: Understanding Catastrophic Risk Modelling

Natural hazard risks are characterised by high severity and low frequency, therefore historical data is typically insufficient for insurance companies to estimate future losses. Instead, they use probabilistic catastrophic risk modelling to estimate the frequency and likely extent of losses. There are four modules to a catastrophic risk model: the stochastic event module, the hazard module, the vulnerability module, and the financial module. The stochastic event module is a database of possible catastrophic events and data on their strength, size, location likelihood etc. The hazard component of catastrophe models assesses the level of physical hazard across a specific geographical area at risk. The vulnerability module calculates the likely amount of damage from each event in a given region. Damage projections are quantified according to a mean damage ratio, which is calculated by dividing the average anticipated loss by the replacement value. Finally, the financial module translates this physical damage cost into actual financial loss figures. The main output from the catastrophic risk model is the exceedance probability (EP) curve that depicts the probability that a certain level of loss will be exceeded on an annual basis. Insurers derive a number of risk estimates from the EP curve, including the annual expected loss and the standard deviation of this loss. They use these metrics (after accounting for commission, expenses, profit loading etc.) to calculate what type of coverage they can offer and the amount they can charge whilst maximising expected profits and minimising the risk of insolvency.

4.2 Hydro-met data availability

Hydro-meteorological[23] data forms the foundation of weather forecasting and climate research, but is also useful to a range of sectors such as construction, healthcare, transport and insurance. Whilst ground-based data is traditionally acknowledged to be the most suitable type of data, the

[23] Hydro-Meteorological data refers to data collected on hydrology (e.g. river flow) and meteorology (e.g. precipitation, temperature, wind speed and direction, radiation)

sparseness of stations in Africa and unreliability of records for stations that do exist has meant that other techniques have been developed to obtain these data.

Table 4.1 provides a general summary of the main sources of weather data and explores how they are used by the insurance market.

Table 4.1 – Climatological Data Sources

Type of data	Brief Description	Strengths	Weaknesses	Availability	Accessibility	Relevance to insurance
IN SITU OBSERVED DATA *Discussed in Section 4.3*	Data collected from ground-based observations stations. Different parameters measured depending on type of station but commonly, tend to be for rainfall, pressure, temperature, humidity, cloud cover and wind needed for synoptic meteorology.	Provides the most accurate record of conditions at a specific location. Observing methods have been consistent over many years. Often the only source of long records. Records extremes.	Errors in readings if equipment not adequately maintained. Only representative of the immediate area around the station. If the terrain is not homogenous with different conditions potentially be experienced 500 meters away. Therefore they cannot give reliable coverage, especially in Africa where the density is low. Hydrological stations are even sparser. Historic records are often on paper and can be lost or damaged.	Most ground based stations managed by National Meteorological and Hydrological Services (NMHS) who will retain data records. Some stations operated by private companies such as tea plantations but density too low to be relevant, and they may be difficult to access. Some NMHS provide data freely but for most these data is a vital source of income or can be considered politically sensitive, so will charge for access to these data. Data can also be found through other government departments and private enterprises but these data would need to be analysed for their accuracy.	A certain amount of data is exchanged between NMHS in real time. Data is not quality controlled and use is restricted. The main archives are held by the respective NMHS. Insurance companies would need to work with NMHS at a country level to secure ground-based data.	Observations are used by the insurance market globally as part of input dataset to catastrophe risk models (used for loss estimation). They are also used directly as trigger parameters in some weather derivatives and other similar transactions.

Type of data	Brief Description	Strengths	Weaknesses	Availability	Accessibility	Relevance to insurance
IN SITU DATA on GLOBAL TELECOMMUNICATIONS SYSTEM (GTS) *Discussed in Section 4.4*	A subset of in situ data, released by NMHS in real time.	Quality controlled by buddy and other consistency checks.	Subset in space and time of all available data. Met Office retains data for a minimum of 10 years. Density of stations on GTS may be too low to provide useful records for indexing and validation purposes.	Information is made available to all NMHSs; Met Office has an archive of these data in a local database.	Needs to be accessed from NMHS databases which will be proprietary.	Density of stations on GTS is too low to provide useful records for indexing and validation purposes, although GTS could be used as a check on NMHS data being used for parameter generation at higher resolution.
RADAR	Tuned to pick up reflections from rain, snow, locusts, dust or other suspended solids or liquids. Range of 200km radius at 1km to 5km grid resolution. Can also be used to infer winds and precipitation phase.	High quality estimates of precipitation at 5 minute resolution. Able to identify cloud bursts leading to local flash floods.	Ground-based, needing to be maintained by local staff. Breakdowns can take a long time to repair or go unrepaired. Numerous radar have been installed in SSA but few still in Operation. Very limited geographical coverage where multiple radars are not 'networked' to provide national coverage.	Data rarely archived.	No known exchange protocols exist for Africa.	Identification of location, time and intensity of intense rainfall. Used in UK to produce return periods used by insurers.

Type of data	Brief Description	Strengths	Weaknesses	Availability	Accessibility	Relevance to insurance
REMOTE SENSING DATA – SATELLITE Products: GPCP, TRMM, TAMSAT *Examples of satellite products in Annex 9*	Provide image derived and sounding data. Images provide information on cloud cover and winds. Soundings provide information on humidity. Polar Orbital satellites give low orbit detail twice a day from two satellites, i.e. a snapshot every 6 hours. Geostationary satellites provide constant coverage, but the high orbit reduces spatial detail.	Full coverage of Africa without the need to involve local support. Not affected by human/ equipment factors in the same way as ground-based stations. A high level of hardware redundancy maintains a constant flow of data.	Very large volumes of variable quality data which requires sophisticated processing. Quantitative information relevant to insurance, principally rainfall, at early stages of being inferred from other parameters. Rainfall derived from satellite relies on ground surface stations for calibration. Due to the sparsity of ground networks in Africa, this means that there is low confidence in the absolute amounts of rainfall detected by satellites. Data from different satellites can be inconsistent. GPCP is not available in real time. Wind data depends on the presence of cloud and are highly variable in terms of the altitude they are recorded and quality.	Large archives held by larger NMHSs such as European and American Weather Services. Substantial post-processing needed to make data routinely available. Expensive, so data is collected by international agreement. The gathering of quantitative data from satellites is still developing and could lead to spatially high resolution data of useful quality in due course. This offers the prospect of being able to differentiate ever smaller weather features.	Data volumes make accessibility channels challenging and expensive to develop. Some data is freely available online.	Good at identifying the location and duration of storms, but less good at gauging surface severity of wind and rainfall. Used by insurance sector in a number of index insurance programmes e.g. vegetation indices, such as the normalized difference vegetation index (NDVI) or the enhanced vegetation index (EVI).

Type of data	Brief Description	Strengths	Weaknesses	Availability	Accessibility	Relevance to insurance
NUMERICAL WEATHER PREDICTION (NWP) ARCHIVES *Discussed in Section 4.8*	NMHSs that run NWP models (e.g. US, UK, France, Germany) store some or all of the products. Data is on 3D grids, varies in spatial resolution, with temporal resolution of 1 to 6 hours. A wide variety of atmospheric descriptors are available.	Full geographic coverage. No need to involve local NMHS Wide range of observations sources (especially satellite) used to initialise models to current atmospheric state. Current model spatial resolution capable of regional detail.	Not easy to quantify accuracy in data sparse areas. Models change in ways that introduce step changes in parameter time series (major changes approximately every five years). Output data varies depending upon the NWP model used.	Met Office (UK) holds data back to 1993, initially on 90km grid, then 60km (Jan 1998), 40km (Dec 2005), 25km (Mar 2010), 12km (Jul 2014) then 10km (July 2017) ECMWF holds archives of ERA40 on ~ 125km grid (Sep 1957 – Aug 2010) and ERA-Interim on ~80km grid (Jan 1979 to present)	Extraction of long time series to create climatologies is time consuming and needs to be done by an NMHS. These data are not publicly available.	Parameters of interest are covered quantitatively with complete geographical coverage, but the quality may be insufficient.
REANALYSIS DATA SETS *Discussed in Section 4.8*	Six-hourly snapshots of the atmosphere produced using a consistent methodology for drawing all the observational data sources together. Some extend back over 100 years.	Consistent analysis methods and grid size. Complete dataset over space and time.	Small features can slip through the large grids and long time steps. Not updated in real time. Not operational, so no guarantee of continuance, but	European Centre of Medium-range Weather Forecasting (ECMWF), National Centre for Atmospheric Research (NCAR) and others	Mostly freely available, especially if produced in the US. Some only available to contributing NMHSs	Relevant data, but resolution and quality limits their use. Best suited to creating national scale averages of weather features with a persistence of at least a day, i.e. large storms.

			replacement would happen. Output data varies dependent upon the reanalysis method adopted.			

Type of data	Brief Description	Strengths	Weaknesses	Availability	Accessibility	Relevance to insurance
SEASONAL FORECASTS AND CLIMATE MODEL PROJECTIONS *Discussed in Section 4.9*	Global models are used for seasonal and longer range timescales and a range of models cover the African continent at a spatial resolution of approximately 25km, with areas of higher resolution provided in some parts by Local Area Models (e.g. Lake Victoria area has a 4km model and North Africa down to Tanzania at 12km run by the Met Office; ECMWF HRES model on a 0.1° x 0.1° grid)	Climate change and natural variability mean historic reference is not always an appropriate baseline Consistent grid size and defined method Complete dataset over space and time	Data varies depending upon the NWP model used – continual improvement means consistency of method cannot be guaranteed. Data requires professional interpretation.	Major NMHS's	Varies dependent on NMHS, resolution and region	Not yet in mainstream use within insurance industry, but research is ongoing to build climate projections into medium-term business planning processes.

4.3 In-Situ Data from National Meteorological Hydrological Services (NMHS)

In-situ observations have traditionally been regarded as one of the most valuable data sources for the insurance industry, access to these data was therefore examined by this project. An email requesting information about their records and whether the data provided for free, was sent to Directors at National Meteorological and Hydrological Services[24]. The countries concerned included Kenya, Malawi, Rwanda, The Gambia, Ghana, Sierra Leone, Zambia, Lesotho and Cameroon.

In March 2018, the Kenya Meteorological Department (KMD) provided the following response:

Data available:

Rainfall data - Approximately 2900 stations digitized from 1921 to 2017
Temperature data - Digitized from 1979 to 2016 (29 stations).
Wind data - Digitized from 1985 to 2014 (24 stations).

They further explained that; ‘The KMD policy is not to sell raw data but processed (e.g. averages, totals, extremes etc.). Quality Control procedures are in place that include double key entry for removing typos, limits / range checks and inter elements comparisons (internal consistency). KMD has mechanisms for cost recovery in data supply.’

As of March 2018, no reply had been received from the other 8 counties.

Ethiopia, Kenya, Tanzania[25] and South Africa are all known to have good data records but these are charged for as these NMHS all have cost recovery mechanisms in place.

There is an ongoing discrepancy over the whole issue of data charging. NMHSs have been urged by their governments and the World Bank to establish cost-recovery mechanisms, in order to improve financial support of their activities. This approach is somewhat at variance with WMO resolutions on data sharing and availability, as summarised in the Box 4.2 below.

BOX 4.2: WMO resolution 40

WMO Resolution 40 governs the exchange of meteorological data (Appendix 10) and dictates that basic data to protect life and property should be made freely available for non-commercial purposes at the cost of production and dissemination. GTS is used for the exchange of this data between NMHS for global modelling, and for other users it is available by request to NMHS.

Even where NMHS do not have formal cost recovery mechanisms in place, historic data records represent their most valuable assets and the services therefore tend to be cautious about releasing it without a good understanding of how it will be used. In the Met Office’s experience, requests for data are much more likely to be successful when made **face to face** and when the project in question maybe of some benefit to the particular service.

[24] Meteorological and hydrological functions are often fulfilled within the same institution, known as Meteorological and Hydrological Services but there are sometimes separate meteorological and hydrological services within a country.

[25] Details of Tanzanian Meteorological Agency own archive is given in Section 5

As the Met Office has worked closely with NMHSs across Africa, the size and capacity of NMHSs was explored to provide an indication of which countries may have the networks and databases needed to support insurance instruments. Anecdotal accounts of data gathering processes and systems were also collected as these may be relevant in Phase 2 of the project when datasets have been obtained.

BOX 4.3: NMHSs in Africa

- NMHSs are being encouraged to implement Quality Management Systems in their aviation offices (ICAO[26] requirement) and throughout the organisation. If an NMHS is accredited this could improve the availability and quality of real time data.
- Records for many countries date back to the colonial period and are often available in manuscript but less so in a digital format.
- Gaps in data records are common due to conflict, power cuts (for Automatic Weather Stations - AWS) and a lack of spare parts for equipment, though continuous records can often be found at airport observation stations.
- Most countries tend to have a good network of rain gauge stations but often data is only sent to the HQ on a monthly basis (whilst synoptic station data is usually sent every hour).
- Historic weather data is often not digitised and paper records are in bad condition due to poor storage facilities and practice.
- Lack of training can mean that poor maintenance and calibration of observations equipment leads to inaccurate readings.
- ‘Informal’ sources of data, which is classed as data not collected by an NMHS, could also be used for indexing. Data is often collected by tea plantations, large farms, health centres etc, though discovery and access to this data can be challenging. Metadata and quality control information for these data are rarely available.
- Climate Adaptation funding often includes projects to install AWS so data flow and accuracy should have improved in recent years. However, we have seen evidence of these being installed without associated training to the NMHS staff on management and maintenance, or on how to integrate AWS data into the services standard data processes. AWSs also contain valuable parts so theft is an issue if they are not within a secure station enclosure.
- Some African nations have weather radar which should provide excellent data (records for validation purposes) on intensity of rainfall. However, due to the same factors described above, these can often be dysfunctional within a few years of installation. Archiving of radar data is problematic and conversion of images to consistent quantitative data is not common practice, even in developed countries.
- Data transfer to an NMHS’ HQ is traditionally done through sending paper records on a monthly basis. For synoptic stations, mobile phones are often used but transfer via mobile internet is now recommended. This allows for an ‘enter once, use forever’ principle whereby observer data can be automatically ingested into a climate database. Insurance providers could negotiate access to these databases with the NMHSs in real-time which would be essential for an insurance scheme to be validated.

As the official national weather and climate service provider, a NMHS would ideally manage any AWSs that are installed through investment in insurance project pilots as any improvement in the network would be of benefit to many sectors.

[26] **International Civil Aviation Organization (ICAO),** a United Nations specialized agency,

If datasets from selected countries are obtained for Phase 2 of the project, their quality would need to be assessed according to the data requirements of the insurance instruments selected for the pilot. However, it is recommended that a wider scale assessment of the selected country's NMHS is undertaken (from quality of observations stations to service delivery mechanisms) to establish how much investment would be needed in the service in order for it to meet the data needs of the insurance sector. Appendix 4 provides an indication of what high, medium and low investment scenarios may look like.

Following the adoption of the Global Framework for Climate Services in 2012 by the World Meteorological Organisation, it is possible that insurance services could form part of a 'national framework for climate services' at a country level. There are also now multiple funded programmes by International Funding Institutes which are investing in Hydromet Modernisation projects across Africa and Asia; (WB[27], UNDP-CIRDA[28], DFID WISER[29] , WB&WMO CREWS[30] initiative etc.). World Bank GFDRR and WMO have established a Global Weather Enterprise[31] forum to progress public private partnership discussions between NMHSs and private sector. Input from the insurance sector would be very welcome to help inform how these two sectors can benefit each other.

4.4 GTS Data

The current African synoptic network is shown in Figure 4.1. Synoptic data are archived in the Met Office's database (MetDB). The precipitation data includes 6, 12, and 24-hour accumulations, generally observed at 06:00 hrs. However, it also includes data for different accumulation periods and different timestamps, which can lead to substantial ambiguity of temporal assignment. Precipitation data were extracted for 33 open stations in Sub-Saharan Africa from 1983 to 2017. They were examined in terms of data returns compared with expected returns for 24-hour accumulations (Appendix 12). This provides a useful coarse indicator of operational reliability and consistency. However, it does not give an indication of individual station data which may be necessary in subsequent phases in order to provide a quality check on national met service data being used for parameter generation at higher resolution.

4.5 Satellite Data Products

Polar orbital and geostationary satellites provide imagery of global cloud cover, which can be analysed to provide qualitative information on rainfall distribution, and general quantitative estimates of rainfall intensity, and with the appropriate image reception facilities, can be useful for near real time of current events. Like GTS data, satellites can provide historic database information (up to 30 years) and real-time data and have the advantage of covering the whole continent. Examples of these products can be seen in Appendix 13. A number of products are available including GPCP, TRMM and TAMSAT with their operating agencies, but not necessarily at individual NMHSs. Dataset availability over Africa for these products is summarised in Tables 4.2, 4.3 and 4.4 below.

[27] http://www.worldbank.org/en/programs/africa_hydromet_program
[28] http://adaptation-undp.org/projects/programme-climate-information-resilient-development-africa-cirda
[29] https://www.metoffice.gov.uk/about-us/what/international/projects/wiser
[30] http://www.crews-initiative.org/en
[31] https://www.gfdrr.org/en/publication/report-global-weather-enterprise-seminar

4.6 Precipitation dataset availability in SSA

As part of the Met Office's DFID-funded Climate Science Research Programme, a project by Parker, Good and Chadwick (2012) recorded the status of observational dataset availability for climate monitoring, future attribution, and for forecast evaluation. This summary was reviewed and updated in March 2018. Tables 4.2, 4.3 and 4.4 below provide a summary showing what precipitation data sets are available in daily, 10 day and monthly accumulations.[32] An explanation of these datasets and information on their quality can be found in Appendix 14, together with a discussion of their quality. Recommendations of the best datasets (for the purposes above) have been shaded in green in Tables 4.2, 4.3 and 4.4.

[32] A summary of datasets available for temperature on these time scales is also available but precipitation was felt to be relevant for flood and drought hazards.

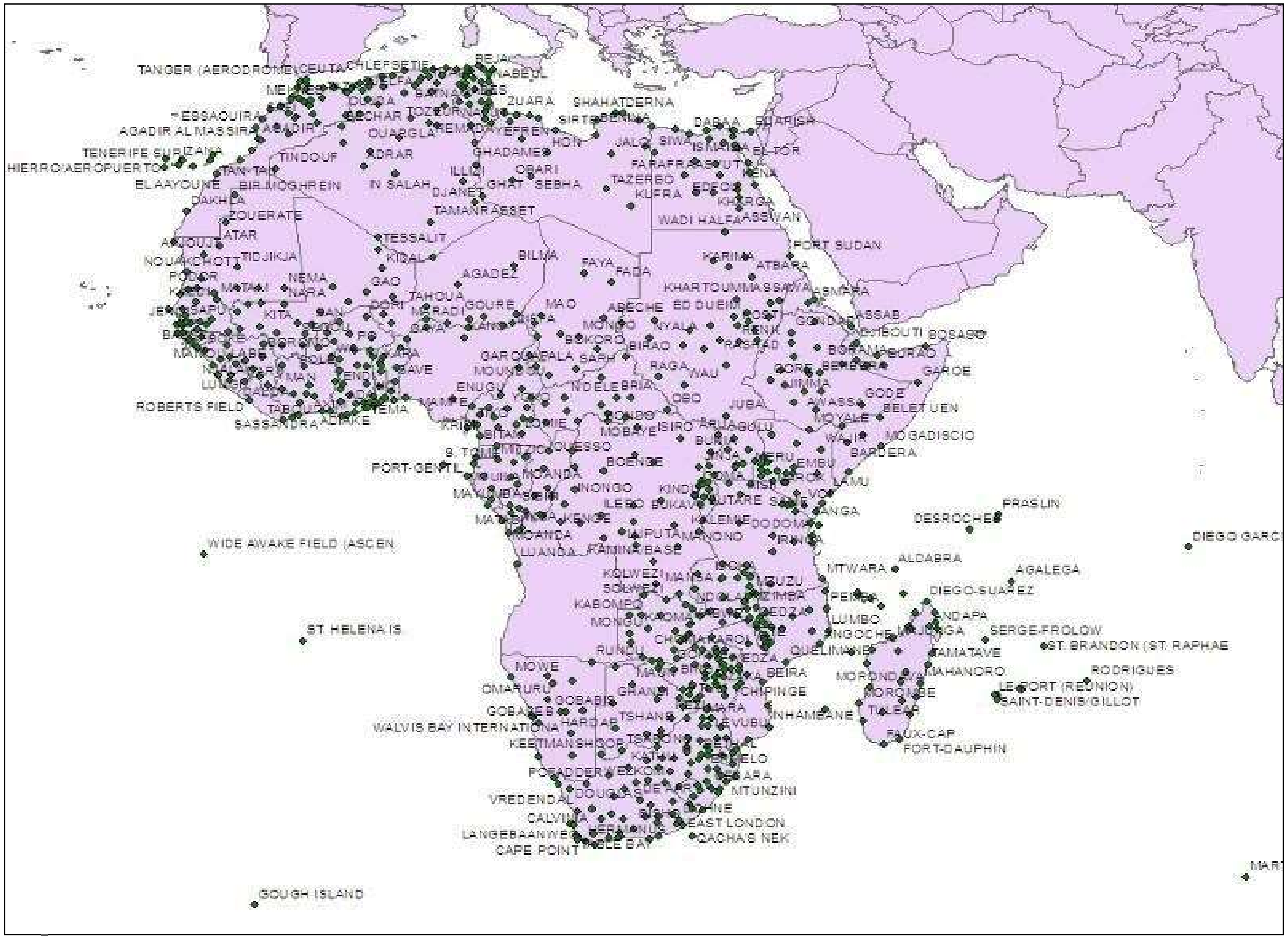

Fig 4.1: GTS Stations in Africa

When priority countries have been agreed and insurance instruments for the pilot phase chosen, a specific assessment should be conducted as to whether these datasets could be used to meet the historic and real time data requirements of the tool chosen. It should be noted that most of these data sets provided data on a grid basis, which have been arrived at through interpolation from point measurement or pixel-based sources. Ground-truth sources (rain gauges) are sparse and the coarse grid scale makes it hard to resolve local area and point rainfalls.

Daily precipitation datasets

Dataset	Spatial Res.	Spatial Coverage	Temporal Coverage	Variables	Data
GHCN-D	Station	Global	19th C.-present	Total precipitation	Gauge
CPC gauge	0.5°	Global	1979-present	Total precipitation	Gauge
TRMM	0.25°	50°S-50°N	1997-present	Rain rate (mm/day)	Satellite
GPCP	1°	Global	Oct 1996-present	Rain rate (mm/day)	Satellite
GPCP GPI	1°	40°N-40°S	1996-present	Rain rate (mm/day)	Satellite
CMORPH	0.25°	60°N-60°S	2002-present	Rain rate	Satellite
CPC-RFE 2.0	0.1°	40°S-40°N, 20°W-55°E	1995-present	Rain rate (mm/day)	Gauge & satellite
CPC-ARC 2.0	0.1 °	40°S-40°N, 20°W-55°E	1983-present	Rain rate (mm/day)	Gauge & Satellite
CIP	Various	African continent	Prototype	Rain rate (mm/day)	Various
TAMSAT	4km	All Africa Land only	1983-present	Total precipitation & anomaly	Satellite
CHIRPS	0.05°	50°S-50°N	1981-present	Rain rate (mm/day)	Gauge & Satellite

Table 4.2 – Summary of daily precipitation dataset availability

10 day precipitation datasets

Dataset	Spatial Res.	Spatial Coverage	Temporal Coverage	Variables	Data
GHCN-D	Station	Global	19th C.-present	Total precipitation	Gauge
CPC gauge	0.5°	Global	1979-present	Total precipitation	Gauge
TRMM	0.25°	50°S-50°N	1997-present	Rain rate (mm/day)	Satellite
GPCP	1°	Global	Oct 1996-present	Rain rate (mm/day)	Satellite
GPCP GPI	1°	40°N-40°S	1996-present	Rain rate (mm/day)	Satellite
CMORPH	0.25°	60°N-60°S	2002-present	Rain rate	Satellite
CPC-RFE 2.0	0.1°	40°S-40°N, 20°W-55°E	1995-present	Rain rate (mm/day)	Gauge & satellite
CPC-ARC 2.0	0.1 °	40°S-40°N, 20°W-55°E	1983-present	Rain rate (mm/day)	Gauge & Satellite
TAMSAT	4km	All Africa Land only	1983-present	Total precipitation & anomaly	Satellite
CHIRPS	0.05°	50°S-50°N	1981-present	Rain rate (mm/day)	Gauge & Satellite

Table 4.3 – Summary of 10 day precipitation dataset availability

Monthly precipitation datasets

Dataset	Spatial Res.	Spatial Coverage	Temporal Coverage	Variables	Data
GHCN	Station	Global	19th C-present	Precip total.	Gauge
GPCC first guess	1.0° & 2.5°	Global	Oct 2003 - present	Precip total	Gauge
GPCC monitoring	1.0° & 2.5°	Global	1986-present	Precip total	Gauge
GPCC reanalysis	0.5°, 1.0° & 2.5°	Global	1901 - 2013	Precip total & anomaly.	Gauge
GPCC VASClimO	0.5°, 1.0° & 2.5°	Global	1951 - 2000	Precip total	Gauge
GPCC gridded climatology	0.25°, 0.5°, 1.0° & 2.5°	Global	1951 - 2000	Precip total	Gauge

Dataset	Spatial Res.	Spatial Coverage	Temporal Coverage	Variables	Data
CRU	0.5º	Global	1901-2016	Precip total, wet-day frequency	Gauge
University of Delaware	0. 5º	Global	1900-2008	Precip total.	Gauge
NCDC	5º	Global	1900-present	Precip anomalies	Gauge
GPCP	2.5º	Global	1979-present	Rain rate (mm/day)	Gauge & satellite
CMAP	2.5º	Global	1979-present	Rain rate (mm/day)	Gauge & satellite & model
TRMM	0.25º	50°S-50°N	1998-present	Rain rate (mm/hour)	Gauge & satellite
CAMS-OPI	2.5º	Global	1979-present	Rain rate (mm/day)	Gauge & satellite
CPC-RFE 2.0	0.1°	40°S-40°N, 20°W-55°E	1995-present	Rain rate (mm/day)	Gauge & satellite
CPC-ARC 2.0	0.1°	40°S-40°N, 20°W-55°E	1983-present	Rain rate (mm/day)	Gauge & satellite
TAMSAT	4km	All Africa Land only	1983-present	Precip total & anomaly	Satellite
CHIRPS	0.05°	50°S-50°N	1981-present	Rain rate (mm/day)	Gauge & Satellite
ENACTS	Various	Selected countries	Various	Precip total	Gauge & Satellite

Table 4.4 – Summary of monthly precipitation dataset availability

4.7 Hydrological data

The availability and quality of hydrological data, regarding river levels and discharge is known to be widely less satisfactory than is the case for rainfall data and other meteorological parameters. There are numerous reasons for this, ranging from finance and governance to equipment provision and general departmental capacity. This is magnified by the heterogeneous nature of river levels and physical impacts of floods.

Both WMO Resolution 25 and Resolution 40 stipulate the requirement for 'free and unrestricted access hydrological data for services in support of protection of life and property' (see definition above). These two resolutions were formally approved by Congress some time ago (1999 and 1995 respectively), but work is still ongoing for these resolutions to be implemented practically by NMHSs. In addition, the WMO have published guides and checklists for developing a Quality Management System for National Hydrological Services; http://www.wmo.int/pages/prog/hwrp/qmf-h/checklist.php.

The WMO Hydrological Observing System (WHOS; https://public.wmo.int/en/our-mandate/water/whos) is a portal to the online holdings of National Hydrological Services (NHSs) around the world that publish their historical observation and/or real-time data without restrictions or cost. However, many of these sites demonstrate that live or archive water level or discharge data are not currently accessible through the websites. Like meteorological records, access to hydrological data (where institutions are separate) is most likely to be achieved through direct contact with a hydrological institute.

In the absence of data published by individual NMHSs, centralised databases such as that of the Global River Data Center, hosted by the German Federal Institute of Hydrology, (http://www.bafg.de/GRDC/EN/Home/homepage_node.html), and the River Discharge Database, University of Wisconsin (https://nelson.wisc.edu/sage/data-and-models/riverdata/) provide accessible and reliable sources of archive data. However, examination of these sites for a sample of countries shows many gaps in records and very limited data for recent years.

The Dartmouth Flood Observatory site provides an increasingly comprehensive record of flood events since 1985 and also a qualitative illustration of current flood extent (updated within 1-2 days of measurement) from satellite sources. Increasing amounts of recent flood information are compiled on other sites such as FloodList[33]. Regular, routine examination in countries and basins of interest could provide a good 'first-pass' at ongoing flood situations, which could be matched to other disaster related information.

There is however a recent and exciting initiative led by the WMO Commission for Hydrology which is intended to provide an operational WMO system 'capable of assessing the current hydrological status and its likely near-future outlook (sub-seasonal to seasonal time frames) for all areas of the globe'. The Global Hydrological Status and Outlook System (HydroSOS; www.wmo.int/pages/prog/hwrp/chy/hydrosos/index.php) has the ambition to develop a worldwide operational system at monthly timescales capable of providing:

- An indication of the current global hydrological status (including groundwater, river flow, soil moisture);
- An appraisal of where this status is significantly different from 'normal' (for example, indicating drought and flood situations);
- An assessment of where this is likely to get worse over coming weeks and months

The system will be delivered by NMHS, offering simple, accessible hydrological information to users such as government bodies, basin managers, funding institutions, aid agencies, UN bodies, and the general public. It is intended that HydroSOS will be developed in phases, with the pilot phase running to 2020. Under this phase, several possibilities for basin pilots are being considered with an initial main focus in Africa and South Asia.

Another system being developed further is the Global Flood Awareness System (GloFAS; http://globalfloods.jrc.ec.europa.eu/) which provides forecast and real time river level and discharge information for a selection of locations around the globe. This initiative has developed jointly by the European Commission and the European Centre for Medium-Range Weather Forecasts (ECMWF);

[33] http://floodlist.com/

and can be considered as a 'global' extension to the European Flood Awareness System (EFAS; https://www.efas.eu/)

4.8 Numerical Weather Prediction (NWP) forecasting and reanalysis data

In-situ ground-based observations and remote sensing data from satellites can (if robust and representative) provide the best record of the past conditions that lead to flood, drought and cyclone events. If they span back a sufficient length of time, the frequency of these conditions can be assessed to provide an estimate of how often they are likely to occur (e.g. once in 5 years).

Where these are not available, forecasting models based upon NWP can be run to represent the past climate and can simulate the atmospheric conditions which occurred during hazardous events and allow an assessment of the frequency of such patterns.

The production of a reanalysis consists of using the observational archives to reproduce, usually every six hours, the gridded initial conditions that are used by NWP models as the basis for their forecast. The model reanalysis uses the NWP algorithms available at the time of construction, meaning that the output is consistent for the period of the data set. Reanalysis databases extend into the past as computer time and observational archives permit.

With a horizontal grid spacing of 50-100km and time steps of 6 hours, reanalyses provide a useful (arguably the best) source of baselining information for weather features that can be differentiated on a spatial scale of a few hundred kilometres and persist for more than a day.

Many reanalysis archives are also extended forwards as time passes, but on a somewhat ad hoc timetable. These data are therefore not available for the immediate analysis of extreme weather events as they happen.

4.9 Climate models and seasonal forecasting data

Anecdotal sources suggest there is increasing inter-annual and seasonal variability being experienced in various parts of Africa. This can result in weakening or intensification of expected rains or irregularity of timing of wet and dry seasons.

As many countries in Africa anticipate regular seasons, and hence socio-economic activities (particularly agriculture) tend to be planned by individuals and government departments alike around these seasons, e.g. for seed and fertilizer distribution, unexpected weather can have a significant impact.[34]

Whilst research in this area is ongoing, higher inter-annual and inter-seasonal variability has been attributed to anthropogenic climate change. Climate records provide evidence that the climate is constantly changing, but historic data alone does not necessarily constitute a reliable source of

[34] For example, Malawian government sources explained that when the latter takes place farmers plan crops thinking that rainy season has arrived but these fail when dry conditions return. Last year this led the Malawian Government to request over $40 million in food aid. Similarly, through the Met Office's contact with numerous African NMHS through WMO, Regional Climate Outlook Forums has indicated that this is happening in other countries and, furthermore that indigenous techniques farmers use to predict seasons (e.g. animal behaviour) are also being disrupted by inter-seasonal variability.

determining what future climate will be. The need for model-based climate data projections may therefore be relevant to climate-based insurers in Africa.

Weather forecasting has benefit to both operational and response actions, but also in relation to planning and preparedness. Forecasts are available on short (1-5 day), medium (6-15 day), and long-range timescales (15-90 days), the latter being extended in some cases to seasonal timescales.

Global models are used for all of these timescales and a range of models cover the African continent at a horizontal resolution of the order of 25km grid, with areas of higher resolution provided in some regions by Local Area Models (e.g. Lake Victoria area has a 4km model and North Africa down to Tanzania at 12km run by the Met Office)

Of all forecasting timescales, seasonal is probably most relevant to climate-based insurance in Africa. Seasonal forecasts provide an estimation of the probability that temperatures and rainfall in the season ahead will be above, near or below average. Commonly these forecasts are given in terms of 3 or 5 categories from low to high, relative to climatic norms (averages). Current practice is increasingly assigning a probability rating for each category to be realised over the forecast period. Seasonal forecasts can also be used to estimate the activity of hurricane seasons, and so are useful to the Re-Insurance market that use them as one of the factors to inform Catastrophe Models.

Seasonal forecasting is a developing area of science but some the highest global skill results are achieved over Africa, due to the large scale atmospheric systems which operate over the continent in general. For example, Western Africa has been a focus of international research into precipitation forecasting[35] and there is therefore good seasonal skill in the Sahel region. Skill for East Africa is not so high, particularly for the March-May rains where large scale convection is less consistent and can make a significant difference to general circulation patterns. However, there are initiatives which are starting to address these gaps through programmes such as WISER- SCIPEA[36] where partnerships between the International Research Institute for Climate and Society (IRI), IGAD (Intergovernmental Authority on Development) Climate Prediction Applications Centre (ICPAC), Met Office, the meteorological services of Ethiopia, Kenya, Tanzania and Uganda, educational institutions and end users of seasonal forecasting information in the region and from the four countries are being strengthened. A core part of the project involved enhancing links and data exchanges between global, regional and national climate organisations in order to strengthen resources and tools for seasonal forecasts. This project has facilitated the co-development of tailored services with climate information providers and users. The long-term aims of the project involved NMHSs, universities and training centres working together in the region to strengthen training resources and the capacity for climate service development.

[35] For example, the AMMA project which combines the expertise of a number of global forecasting centres. The Met Office's CSRP programme is trying to improve understanding of East African precipitation
[36] https://www.metoffice.gov.uk/about-us/what/international/projects/wiser/scipea

BOX 4.4: Post-disaster loss and damages information for insurance companies

Richer post-event information about the occurrence, impacts, characteristics and thresholds of floods, droughts and storms may be available at a country level from the government sector mandated to collect these data (e.g. in Rwanda, the Ministry of Disaster Management and Refugee Affairs) and through the CRED database. It is recommended that these data are obtained and assessed so that insurance companies can verify losses and improve risk models. This type of data could also be used where insurance tools are being developed to reduce urban flood risk, as disaster databases do not tend to capture hazard information at a city-level. Ethiopia's National Disaster Risk Management Committee[37] (NDRMC – previously DRMFFS) has demonstrated good practice through their development of Wereda Risk Profiles at district level. These profiles capture community level vulnerability information of essential use for developing impact-based forecasts for nowcasting through to seasonal timescales. This information is gathered at district level and fed up through the NDRMC networks to Regional and National level.

4.10 Country capacity for weather data

4.10.1 Governance

Governance has been identified as another factor which influences the success of climate risk financing, so this has also been included in the database as a means of assessing readiness. Data on governance was obtained from the Ibrahim Index of African Governance which provides an annual assessment of governance performance in Africa using 88 indicators drawn from 23 independent international data providers. http://www.moibrahimfoundation.org/IIAG/ (Appendix 16).

4.10.2 Development of Insurance Market

With the exception of South Africa, the state of the traditional insurance sector for catastrophe insurance is at a relatively low level throughout the continent. However, there are a few insurers in Kenya, Ethiopia and Ghana who are gaining experience through partnering with development agencies on pilot projects. However, the overall capacity for developing innovative weather insurance tools (either index or indemnity) is still fairly limited outside of RSA.

4.10.3 Countries with existing donor dialogue and support in risk financing and insurance

Another consideration is countries where donor support is available to enable insurance and risk transfer markets. These include: Ethiopia, Kenya, Senegal, Ghana, Benin, Burkina Faso, Uganda, Rwanda, Tanzania, Mozambique, Malawi, Zambia, Zimbabwe. Countries where DRFI (Disaster Risk Financing & Insurance) dialogue is continuing are: Senegal, Mali, Burkina Faso, Ghana, Togo, Malawi, Mozambique and Madagascar. Humanitarian agencies interest in provision of Forecast Based Financing [38] is growing exponentially from the Red Cross Climate Centre & World Food Programme co-funded Forecast Based Financing initiative to the longer established Africa Risk Capacity solution, originally funded by DFID and supported by WFP, IFAD, USAID and more - now managed at a regional

[37] http://profile.dppc.gov.et/Default.aspx
[38] https://www.climatecentre.org/programmes-engagement/forecast-based-financing

level through the African Union specialised agency.[39] DFID is also partnering with the World Bank and the German Government to fund and manage a Centre for Global Disaster Protection.[40] The centre will harness key expertise across these agencies and with partners to use existing disaster risk finance mechanisms and to create new ways to support the poorest countries to strengthen their disaster planning. Ideally, forecast based financing and insurance schemes will be used to enable countries to better manage the economic impact of emergencies and build future resilience.

4.10.4 Collation and ranking of data to indicate a country's readiness for climate risk financing

Sections 3.2, 3.3 and 3.4 describe how an assessment of whether a country would benefit from climate risk financing has been undertaken by considering climatological predisposition of SSA countries to floods, droughts and cyclones, recorded occurrences of these hazards and their impacts and socio-economic economic vulnerability.

Identification of countries which are ready for climate risk financing has primarily been influenced by the availability of hydro-meteorological data as this is fundamental to the development of climate risk financing. It is recognised that other factors also impact upon 'readiness' including socioeconomic, cultural and legislative influences; however, a complete review of these factors is beyond the scope of this report. The database compiled for assessing which countries would benefit from financing has therefore been expanded to include information on the density of stations reporting to the GTS (the ten countries with highest density are marked in grey), where there are large and well-resourced NMHS (countries marked in grey) and where there is good seasonal forecasting skill (countries marked in grey). The datasets shown in tables 4.2, 4.3 and 4.4 are global and therefore have not been incorporated for cross comparison purposes, but may be relevant for insurance schemes to consider in phase 2.

The countries with the top 10 scores for governance have also been marked in this section of the database as have countries with well-developed insurance markets and those which are strategic priorities for the World Bank.

4.10.5 Identification of priority countries

After populating the database with data on which countries would benefit and be ready for climate risk financing from a reporting perspective, a cross comparison was made of those which had been marked in across multiple categories. The countries with markings across four or more areas are presented in Table 4.5 below.

[39] http://www.africanriskcapacity.org/
[40] https://dfidnews.blog.gov.uk/2017/07/20/centre-for-global-disaster-protection/

Table 4.5 – Countries most vulnerable to Flood, Drought and Cyclone hazard

Country	Floods	Country	Droughts	Country	Cyclones
Nigeria	9	Ethiopia	9	Mozambique	8
Ethiopia	8	Kenya	8	Madagascar	7
Kenya	8	Niger	6	Reunion	6
Mozambique	7	Mozambique	6	South Africa	6
Sudan	7	Nigeria	5	Cape Verde	5
Ghana	5	Burkina Faso	5	Comoros	5
South Africa	5	Ghana	4	Mauritius	5
Tanzania, Rep of	5	Somalia	4	Swaziland	3
Burkina Faso	5	South Africa	4		
Malawi	5	Tanzania, Rep of	4		
Benin	4	Sudan	4		
Niger	4				
Somalia	4				
Senegal	4				

In order to identify less than ten priority countries for the next phase, those which had a ranking of more than 7 are shaded in red.

4.11 Conclusions

This chapter details the activities undertaken to identify priority countries, which would most likely benefit and be ready for climate risk financing for subsequent phases of this project. In order to assess this, the following factors were used to assess the countries that would benefit from and be ready for climate risk financing:

- Climatological influences which predispose areas to floods, droughts and storms
- Recorded incidence of the floods, droughts and cyclones and their impacts, as reported by a variety of disaster databases
- Aggregate socio-economic vulnerability of countries in Sub-Saharan Africa
- Hydro-meteorological data availability
- Countries with larger and better resourced NMHS (who are therefore more likely to be able to provide data to support pilot climate risk financing instruments -historic and real time)
- Seasonal forecast skill
- Existence of good Governance
- Donor interest in risk finance and insurance market development

A database was compiled to compare the above factors and countries which with a high ranking across multiple factors were identified. These were as follows:

Floods: Nigeria, Kenya and Ethiopia
Droughts: Ethiopia, Kenya, Niger and Mozambique
Cyclones: Mozambique and Madagascar

Through undertaking this assessment a number of recommendations have emerged, which would be relevant when countries and insurance instruments have been selected.

- A general socio-economic vulnerability ranking was compiled from a range of sources. However, a specific vulnerability assessment is recommended when an insurance instrument and specific country have been selected as vulnerability indicators vary widely according to what risk the climate risk financing is trying to reduce.

- The availability of precipitation data on daily, 10 day and seasonal timescales is presented in Tables 4.2, 4.3 and 4.4. The suitability of these data for the purposes of climate monitoring, future attribution, and for forecast evaluation has been assessed but an assessment of its suitability for the range of insurance instruments being piloted is recommended.

- If national climate records are obtained, a detailed analysis of individual station plots is recommended using near-neighbour gauges or remote-sensed observations e.g. satellite and radar if available.

- Detailed post-event information about the occurrence, impacts, characteristics and thresholds of floods, droughts and storms may be available at a country level and it is recommended that in Phase 2, where available, these data are obtained and assessed as this could provide insurance firms with a deeper understanding about the nature of hazards and their effects at a country level.

- Investment in development of high resolution datasets incorporating a variety of data types (including ground-based stations, NWP modelling, satellite information etc.) will improve the likelihood of success and sustainability of climate risk financing pilots. Funding mechanisms for their ongoing production should be explored.

- As the national institute responsible for monitoring and forecasting the weather, it is recommended that investments in improving data also result in wider benefit for the local NMHS (e.g. for Early Warning Systems). An assessment focused around the NMHS' capability to provide the services required by insurers would be needed to define whether investment is needed in the network and if the organisation would be high, medium or low in capacity to deliver.

- As the climate is not stationary and changes in the climate are being observed, it is recommended that forecasting data as well as historic data are considered when determining a country's climatological risk from floods, droughts and cyclones.

- Pilot studies should incorporate assessment of the sustainability of climate risk financing mechanisms from a socio-economic, cultural, political and legislative perspective.

No single source of data provides the ideal material for developing insurance models and identifying significant weather events as they arise. Overall, our recommendation would be to work with reanalysis data to develop models and NWP analyses for real time assessment. There will be a mismatch in terms of the statistics that can be harvested from the NWP model and the reanalysis baselining statistic. It will be necessary for data providers to work in partnership with climate risk financing organizations to understand these differences and enable them to be considered within pricing and risk assessment mechanisms. Supplementary data could be gathered from strategically placed in-situ monitoring made available via the GTS. Such monitoring should be focused on locations where high vulnerability and high hazard probability come together.

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5.0 INSURANCE FOR WEATHER RISK IN SUB SAHARAN AFRICA

5.1 Introduction

This chapter provides an overview of the insurance market in Sub-Saharan Africa. It then provides an inventory and assessment of insurance instruments, both available or with development potential to address weather risk for the different agents in society. A detailed commentary is provided on the compendium of active, piloting or planned weather insurance programmes across Sub-Saharan Africa and an outline of general findings, conclusions and recommendations for further development. Since the original report in 2013 there have been developments in weather data and use of this data. This information is detailed in chapter 5.8.

5.2 Insurance in Sub-Saharan African Context

Several efforts have been made to understand the supply and demand for insurance in Sub-Saharan Africa. This is in itself a daunting task given the size and complexity of these countries and their markets. Some of the more notable studies in the area include:

- Munich Re Foundation and Making Finance Work for Africa's *The Landscape of Microinsurance in Africa 2012* using 2011 data in 39 countries;
- Swiss Re's 2012 *Global Insurance Review* and its presentation to the African Insurance Organisation based on 2011 data for 47 recognised states in Sub-Saharan Africa;
- The MicroInsurance Centre's *Landscape of Microinsurance in the World's 100 Poorest Countries* (2007) based on 2005 data;
- International Labour Organisation's (ILO) Microinsurance Innovation Facility and the MicroInsurance Centre's publication (2009) based on 2008 year end data.

5.2.1 Market Size

Amongst the studies reviewed there is a general consensus that insurance penetration rates (premiums as a % of GDP) are extremely low in Africa, and below the average for emerging markets, with South Africa being the sole exception and accounting for the dominant share of the continental market. Swiss Re (2012) calculated that the SSA share in global gross domestic products remains very low, at 1.1% and its insurance sector accounts for only 0.2% of total global premiums written. Another finding which emerges from these reports is that insurance and microinsurance are on the rise in Africa. The Munich Re (2012) study in Africa (including South Africa) has shown a 200% increase from 2008 to 2011 in the number of insured low-income people, now reaching in excess of 44 million. Swiss Re (2012) calculated that between 2000 and 2011 premium growth averaged 7.1% in SSA and reached USD 8.9 billion in 2011.

Despite this growth, low levels of uptake remains, as confirmed by a 2010 ILO Microinsurance Innovation Facility study which estimated that, across the continent, only 2.6% of the target consumer group is using a microinsurance product (including life and health lines and non-life covers including disaster microinsurance). These findings were also supported by a recent World Bank analysis examining microinsurance activity on the continent relative to microfinance activity and the size of the target consumer group (see Figure 5.1).

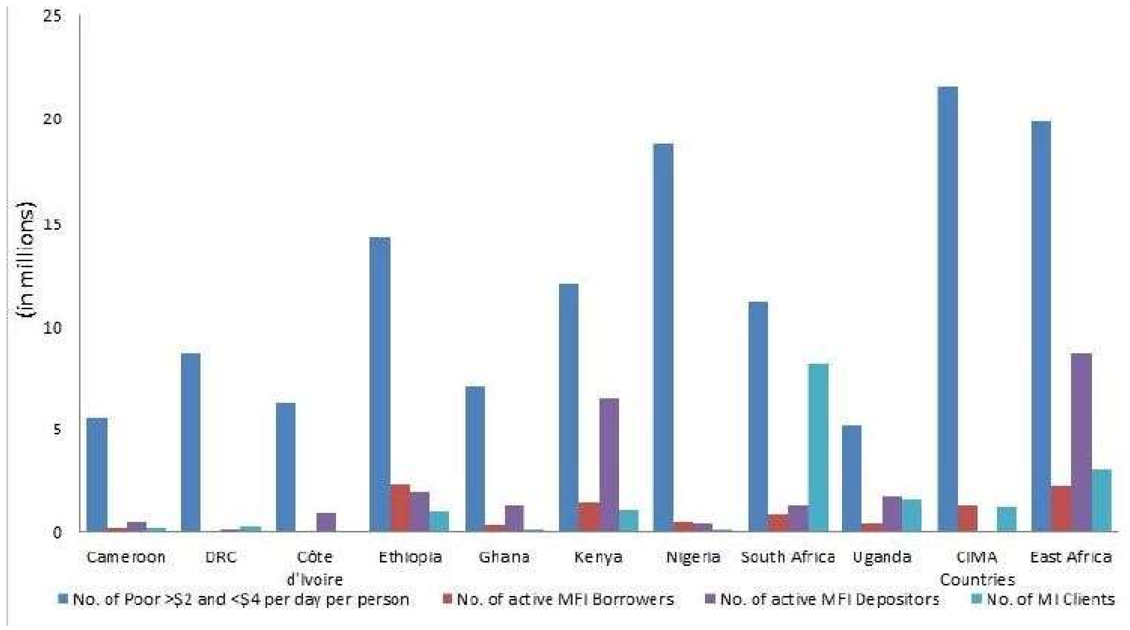


Figure 5.1: Microinsurance (MI) activity in relation to microfinance activity and target consumer group size in Africa. *Source: World Bank, 2012. World Bank Group Micro Insurance Development Program: Concept Note.*

5.2.2 Market Profile

Estimates of the share of life and non-life insurance products in SSA's insurance market diverge significantly between the study produced by Swiss Re and those studies by ILO, Munich Re and Microinsurance. Whilst the latter studies have found non-life insurance penetration to be limited in SSA, Swiss Re has found that they account for two thirds of the total market.

The Microinsurance Centre Study (2012) calculated that both property and agricultural microinsurance premiums barely constituted 1% of the total premium. Munich Re's most recent study in 2012 confirmed these results, observing that whilst the size of the market has dramatically increased the profile has remained the same and life coverage is even more dominant in 2011 than 2008 (see figure 5.2 below). Its results show that the vast majority of those who are insured – close to 40 million people – are still covered by life insurance, while health, agriculture, accident and property are not as developed.

Munich Re's most recent study observed that Southern and East Africa had the largest concentration of insured people, though the regions which experienced the greatest growth were found to be North and West Africa. Central and West Africa were shown to have experienced considerable growth in agriculture and property coverage respectively, whilst the growth of credit-life and health coverage appeared modest across all regions of Africa, with some declines in Southern and East Africa.

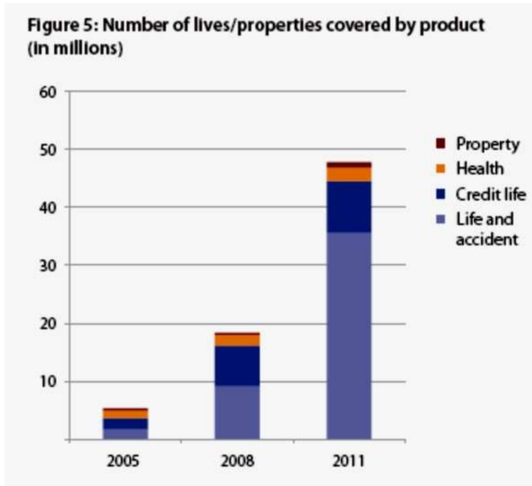
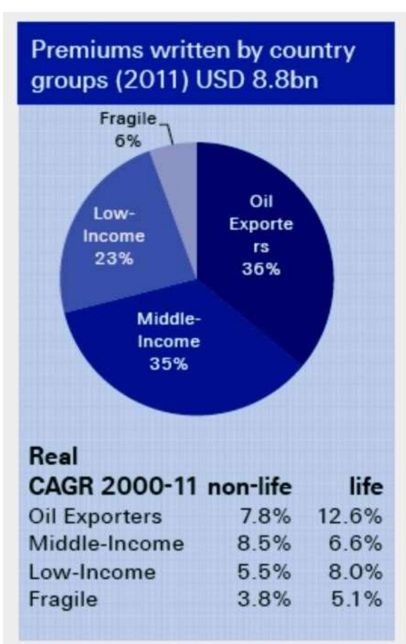


Figure 5.2: Number of lives/properties covered by product (in millions). Source: Munich Re (2012)

Conversely, Swiss Re (2012) found that non-life premiums accounted for two-thirds of the total market, indicative of the dominant role of large multinationals in high-growth sectors such as mineral extraction. Indeed, for non-life they calculated that the bulk of the business was formed by motor and business lines related to the extraction of oil, gas and other non-renewable natural resources. Both in the life and non-life sector individual take-up was seen to be low, and business lines dominated. They also found premium growth to be strongest in oil-exporting and middle income countries, and five of the largest markets – Nigeria, Kenya, Angola, Namibia, and Mauritius – were seen to have a market share of 60%. Swiss Re also measured non life penetration in relation to average income in SSA and found that it was not much lower than would be expected. Life insurance, however, was seen to be well below expectation (see figures 5.3 and 5.4 below).



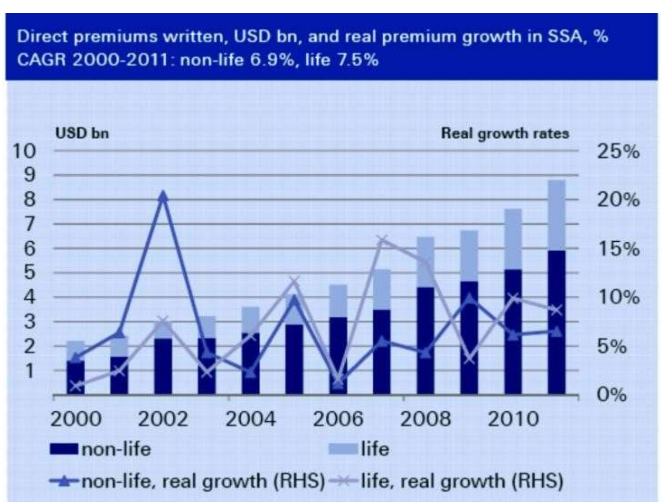


Figure 5.3: Premiums written 2000-11. Source: Swiss Re (2012)

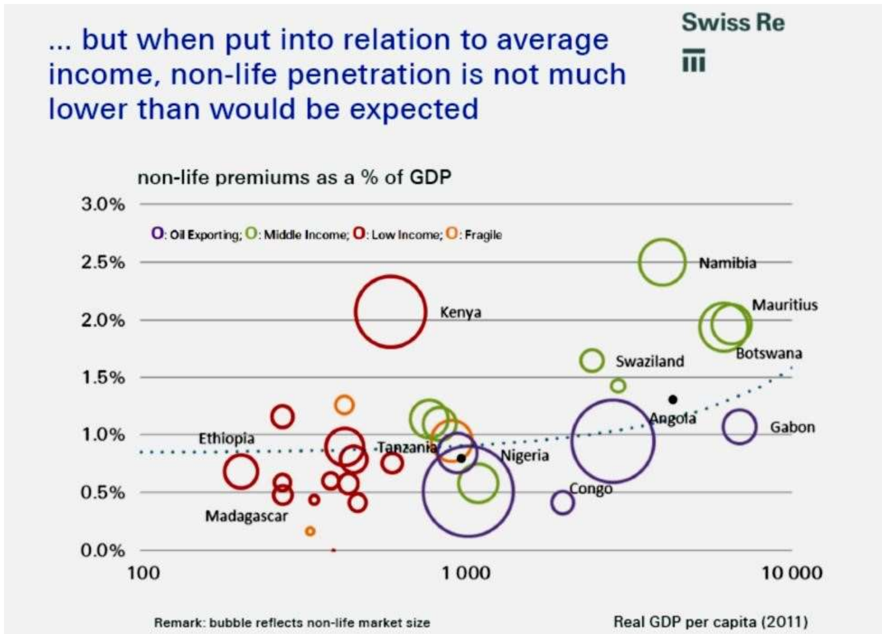


Figure 5.4: Average incomes and Non-life premiums in SSA. Source: Swiss Re (2012)

5.2.3 Microinsurance Providers

Within the studies "insurers" are defined as institutions that manage insurance risk. These include:

- Regulated insurers, which include commercial insurers and cooperative or mutual insurance companies that are regulated by the insurance regulations;
- Health mutuals and community-based microinsurance programs; and
- Microfinance institutions (MFIs), non-governmental organisations (NGOs), hospitals and others that manage their own unregulated insurance programs.

The studies indicated that a wide variety of providers constitute the current microinsurance market in Africa, with the 2009 ILO survey identifying 134 schemes run by regulated insurers, 386 health mutuals or community-based schemes and 24 insurance programs managed by other risk carriers. Munich Re's 2012 study similarly found that community based organisations were dominant, yet they only cover about 12.3% of the total lives and properties covered in all of Africa. Regulated commercial insurers provide cover for over 77.3% of lives and properties covered in the region. Cooperatives provided nearly 60% of agricultural insurance. ILO's survey found that the vast majority of health mutuals were in West and Central Africa. The geographical spread of regulated insurers was more consistent, though they were seen to be slightly more prevalent in West and East Africa. In terms of premiums received, regulated insurers dominate the microinsurance market, representing 88% of premiums received in 2008.

5.2.4 Delivery Channels

Mutuals/community-based organisations and MFIs since 2008 have consistently been the most significant delivery channels, but there has been a substantial effort to broaden the range of delivery channel types. Particularly in South Africa and Kenya, there are experiments with alternative channels such as retailers or mobile phone providers. Scaling up of microinsurance will require improved penetration through MFIs, as well as expansion through other potentially untested delivery channels.

5.2.5 Predictions and Challenges

Through the surveys conducted in these studies some key findings were unearthed in relation to the supply and demand for insurance in Africa. The 2009 ILO survey respondents were asked several questions regarding the limitations to microinsurance expansion in their markets. The results from the survey showed that on the demand side, respondents felt that expansion was hindered most by:

- Potential clients' lack of understanding about insurance (80%); and Their limited ability to pay premiums (72%).

On the supply side, hindering factors were:

- A lack of information technology (78%) High administrative costs (71%); and A lack of qualified personnel (73%).

The study further examined the responses by insurer type and the health mutuals reported that difficulties arise from a lack of technology, management and staff capacity, clients' ability to pay premiums, and access to reinsurance.

Commercial insurers' issues, which are more relevant to agriculture and property coverage centred on reducing administrative costs through technology, as well as scepticism about market demand. In more mature markets, risk carriers see a predominant need for consumer education to facilitate sales and general understanding of insurance concepts.

Munich Re's 2012 survey additionally reported that 67% of respondents agreed that there was a lack of knowledge about insurance needs of the low income population, and 78% said that they felt low income clients were uninformed about insurance. They also cited lack of distribution channels and lack of regulation as additional constraints (though new regulations are being introduced or are under development in CIMA Region Countries, Ethiopia, Ghana, Kenya and South Africa).

Overall most surveys are confident that the market will develop further though they are uncertain to what extent, citing the constraints listed above. Swiss Re (2012) has predicted that SSA insurance sector's current growth rate of 7-8% will continue and insurance premiums could reach more than USD 16 billion by 2017 and USD 25 billion by 2022. There is still great potential for microinsurance expansion and growth in Africa[41], with a range of available products in some countries, such as Kenya, while other settings are dominated by one specific product line. The map below shows that Southern and Eastern Africa dominate the microinsurance landscape. This can be explained partly due to the strength of life microinsurance in South Africa, as well as the engagement of commercial insurers in microinsurance in the East and South.

[41] Note that the number of people covered by product does not match the total number covered due to microinsurance programs offering multiple products to the same clients.

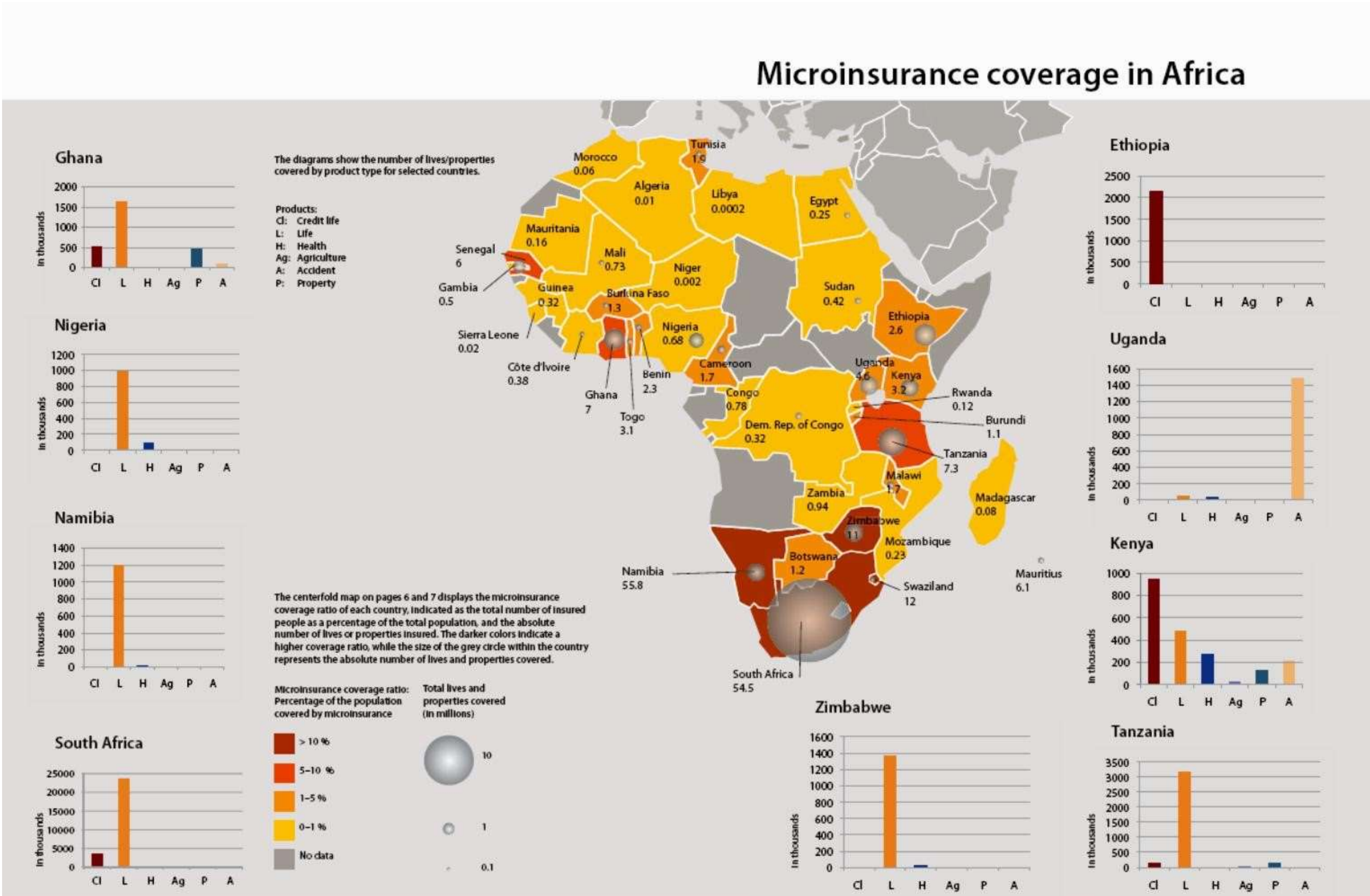


Figure 5.5: Microinsurance coverage in Africa. Source: Munich Re (2012)

5.3 Lessons from Insurance Pilots in Sub-Saharan Africa

New models for insurance provision are being piloted in a number of Sub-Saharan African countries to try and increase the use of insurance by vulnerable populations. Although the spread of microinsurance in Sub-Saharan Africa has centred on life and health insurance as opposed to non-life covers for catastrophe risk, a number of pilots providing innovative index-linked cover to farmers for extreme weather have been launched across the continent (see Box 5.1). These index-linked insurance schemes have sought to provide cover to hard-to-reach segments of the population at lower cost by reducing the need for extensive insurance infrastructure. However, none has yet appeared to prove its potential to scale, or have failed. A number of factors have been cited as inhibiting the growth of these pilots including: lack of demand (see Box 5.2); issues with index data provision or reliability; and lack of suitable distribution networks.

BOX 5.1 Index-linked insurance programmes for African farmers

A number of types of index have been piloted for risk transfer for farmers in Sub-Saharan Africa:

i) Area-yield based indices for Senegalese farmers

Following the authorisation of Senegal's national agricultural insurer (Compagnie Nationale d'Assurance Agricole du Senegal – CNAAS) in 2009, area-yield index based insurance is available to farmers in the country. Area-yield based indices designate a unit area in which a crop cutting experiment is performed to determine yield relative to a historical baseline or predetermined yield threshold for the contract. The contract assumes that the production outcome of insured farmers within the unit is highly correlated. If the crop cutting experiment for the unit indicates a yield significantly below expected levels (as defined at the inception of the policy) then payments are made to all covered farmers within the unit.

Area-yield based contracts can significantly reduce the cost of providing crop insurance as they obviate the need to verify individual farmer's losses. These indices have proven their potential to scale through their use in schemes such as the National Agricultural Insurance Scheme in India which is the largest agricultural scheme globally.

As CNAAS is still at a very early stage in the piloting of these products, the current client base is reported to be limited. However, the company is working with a number of partners to examine options to increase uptake.

ii) Weather-based indices for agricultural borrowers in Malawi

In 2005 the World Bank worked with the National Smallholder Farmers' Association of Malawi to design a weather index insurance product for drought which covered groundnut crops. The product has since evolved and now covers tobacco and maize.

The index-linked insurance product utilises rainfall data from stations managed by Department of Climate Change and Meteorological Services and provides cover for outstanding agricultural loan amounts for farmers in the event of a drought. The product essentially serves to reduce the risk of lending to smallholder farmers and to thereby promote agricultural lending.

The basis of the contract is the correlation between rainfall as measured by weather stations, and crop yields. When a covered drought occurs, rainfall levels drop below historical levels and payments under the contract are made to the financial institution offering the agricultural loan to write off the farmers' debt. The product has been offered through the private insurance market under consortium acting through the Insurance Association of Malawi.

iii) The normalised dry vegetation index (NDVI) for Kenyan herders

The International Livestock Research Institute (ILRI) is leading a project in Northern Kenya to offer index-linked insurance for livestock mortality. An insurance product has been designed using an index based on satellite data; in the event of a drought, the satellite data will indicate changes in the state of the vegetation. As the availability of forage correlates strongly to livestock mortality in the event of a severe drought, the satellite data serves as a proxy for herders' livestock losses. Contracts based on satellite data have broad applicability as third party data providers such as NOAA (the US National Oceanic and

Atmospheric Administration) provide extensive global coverage of this data and make it widely available.

Source: World Bank Disaster Risk Financing and Insurance Program compiled from multiple sources.

There are many lessons to be learnt from insurance pilots in SSA on how to link and interface insurance products within development and adaptation activities. The HARITA and ACCRA programmes described below seek to illustrate this.

5.3.1 Horn of Africa Risk Transfer for Adaptation (HARITA)

5.3.1.1 Project Background

In 2009 Oxfam America and partners (Swiss Re, REST, IRI, Nyala Insurance and others) piloted the Horn of Africa Risk Transfer for Adaptation (HARITA) programme in Ethiopia. The pilot sought to strengthen farmers' food and income security through a combination of improved *resource management* (risk reduction), *microcredit* ("smart" risk taking), *risk transfer* (insurance), and *risk reserves* (savings). It leveraged the existing productive safety net programme (PSNP) in place in Ethiopia by adding an "insurance for labour" option for farmers under the PSNP who were unable to pay for premiums.

The labour exchanged by farmers for insurance was directed towards risk reduction. Qualifying tasks under the programme included activities such as composting and cleaning teff seeds, designed to increase the drought resilience of the participating communities. In return, coverage was granted in the form of weather index insurance. The model suits well on many aspects: apart from having the insurance component, farmers stand to gain even when there is no payout - the risk reduction measures taken in their communities pay dividends, even during good weather years.

In 2009, the take-up rate for the weather index insurance was 20%, with 200 farmers participating in the pilot. 65% of participants paid in labour. The programme has since completed two more growing seasons and available insurance products have been expanded to include additional crops. During the last growing season in 2011, HARITA expanded to 43 villages, covering 13,195 farmers. More than 90% paid for their insurance in labour. The insurance policies paid out for the first time in 2011 with more than 1800 farmers receiving payouts averaging just under $10 per claim. Oxfam America has recently partnered with the WFP to scale up the programme in the form of the R4 resilience initiative, applying the same principles of work-for-insurance and the application of weather-based indices for insurance to other regions in Ethiopia and additional countries.

It is important to note that before launching the exercise, Oxfam was involved in a detailed scoping exercise to assess prevailing adaptive practices, farmers' perception of climatic risks, willingness to subscribe to insurance products through a series of field studies and experiments. They also sought ways of increasing the attractiveness of index insurance by prioritising the core interests of clients, in contrast to the dominant index insurance model which focuses on lenders and insurers. As such, HARITA's project partners recognized that farmers in *Adi Ha* would need to play a central role in the pilot's design. The key and instrumental roles played by farmers in designing the HARITA model included: (i) a participatory capacity and vulnerability assessment involving about 200 farmers, (ii) identification of pilot leaders, representative of the community's socio-demographics, (iii) community participation in pilot exercises and awareness campaigns. Farmers identified a number of ways to enhance the production and yield of teff (the crop favoured for the pilot) as a strategy for reducing risk to drought. Farmers also helped to design a weather index insurance product to complement the risk reduction activities taking place in the village through inputs on filling in climate and weather-risk data gaps, indicating contract preferences, informing and finally selecting the product distribution model and establishing a grievance process to handle farmers' complaints or questions.

5.3.1.2 Key Learning Outcomes from HARITA Model

Given that development practitioners have relatively deep experience with risk reduction and credit, HARITA has focused on exploring the potential and limits of the little understood tool of agricultural micro-insurance. Few existing index insurance projects have reached the stage of actual financial transaction, and most are small-scale pilots or one-year test period initiatives. The key learning points that the HARITA model possible provides include:

i. *How to integrate insurance with risk reduction* – as illustrated by the "insurance-for-work" design that allows insurance and credit to stand as independent components. The independence of credit and risk transfer means that farmers do not lose access to insurance once they have repaid their loans, and that farmers who do not want a loan can still obtain insurance. ii. *How to engage farmers meaningfully in insurance design* – the HARITA example illustrates how process of engagement resulted in a much more attractive product, and improved the financial service providers' ability to educate farmers effectively. iii. *How to overcome weather data barriers* – in *Adi Ha* IRI was involved to explore new techniques to enhance sparse local datasets through a combination of satellite imagery, rainfall simulators, and statistical tools that incorporate information from the closest stations, leading to developing a viable index and an open-source methodology for handling data gaps.

iv. *How to increase insurance take-up by farmers* – culturally appropriate popular education methods developed in conjunction with farmers, such as storytelling and participatory games have helped significantly in dispelling information barriers

5.3.2 Local Adaptive Capacity in Mozambique – The Local Adaptive Capacity Framework of the Africa Climate Change Resilience Alliance (ACCRA)

5.3.2.1 Project Background

The Africa Climate Change Resilience Alliance (ACCRA) is an alliance of five development partners: Oxfam GB, the Overseas Development Institute, Save the Children, World Vision International and Care International. It was established in 2009 with the aim of exploring how existing disaster risk reduction (DRR), social protection and sustainable livelihood interventions affect adaptive capacity at the local level in Mozambique. It does so through the use of the Local Adaptive Capacity framework, which considers five characteristics of adaptive capacity: the asset base; knowledge and information; institutions and entitlement; innovation; and flexible, forward-looking decision-making.

The following figure illustrates the LAC framework and its main features:

Adaptive capacity at the local level	
Characteristic	**Features that reflect a high adaptive capacity**
Asset base	Availability of key assets that allow the system to respond to evolving circumstances
Institutions and entitlements	Existence of an appropriate and evolving institutional environment that allows fair access and entitlement to key assets and capitals
Knowledge and information	The system has the ability to collect, analyse and disseminate knowledge and information in support of adaptation activities
Innovation	The system creates an enabling environment to foster innovation, experimentation and the ability to explore niche solutions in order to take advantage of new opportunities
Flexible forward-looking decision-making and governance	The system is able to anticipate, incorporate and respond to changes with regards to its governance structures and future planning

Figure 5.6: Adaptive capacity at the local level, Source: Jones, Ledi and Levine (2010) 'Towards a characterisation of adaptive capacity: a framework for analysing adaptive capacity at the local level', *ODI Background Note*

ACCRA's research in Mozambique focuses on two of these, namely "knowledge and information", and "innovation". Research was conducted in two case study sites: Chibuto District in the southern province of Gaza, and Caia District in the central province of Sofala.

5.3.2.2 Key Learning Outcomes from ACCRA Model

The key findings of ACCRA's research identify the following:

- Traditional, informal adaptive practices employed by smallholder farmers are grossly inadequate and unsustainable;
- However, certain livelihood-based groups (such as Farmer's Associations), or innovative farmers do have access and capacity to gather and assimilate external information aimed to mitigate the risks. But, such acquired knowledge is highly exclusionary and rarely shared outside groups or close networks;
- NGOs and other development organisations generally tend to overlook local innovations and successful adaptations and have an affinity to impose external knowledge without proper assessments;
- Certain key factors such as socioeconomic heterogeneity and intra-community power needs to be taken into active factoring-in, when external agencies – for example governmentsponsored development programmes, or NGO interventions – propagate capacity-building;
- Adaptive capacity being highly context-specific, government and development agencies need to identify prevailing divisions and tensions and understand contexts carefully before piloting interventions; and

- Institutional barriers such as restrictive property and land-ownership rights, financial illiteracy etc. should be eased out through proper package of intervention products and programmes.

Most of these findings are not ground-breaking, but help to place the key identified factors that can be instrumental in determining whether interventions to strengthen local adaptive capacities will be a success or a futile exercise in Mozambique. More importantly, it flags few risks and insightful understanding on how development interventions affect adaptive capacity. Interventions, for example as found by the ACCRA studies, rarely looks into sustainability aspect and either provides contextually irrelevant advice or attempts to create "everything for them" and provide "everything they need". Cultural practices of risk-aversion and dependency on external hand-outs, thus created, pose tough challenges to engage into when interventions aim to formalise local adaptive practices through systematic and scientific knowledge and encourage innovation. There is also a general tendency to undervalue the role of people's agency – key elements of decision-making and actions that can positively transform and strengthen local adaptive practices – mostly through providing less attention to what people are already doing.

The LCA framework guiding ACCRA's research in Mozambique on local adaptive capacity puts out a few important implications to consider for future interventions and adaptation policies, and possibly, appropriate micro-reviews of NAPAs. These include:

- The importance of supporting people's own agency, which development interventions often miss while attempting to strengthen asset-bases or local institutions – need for intensification of efforts to support people's own agency and their ability to make informed choices and to design and implement their own projects
- Emphasis on participation – either during scoping assessments, piloting interventions and implementing them, across all population groups
- Stress on flexibility and scenario-planning
- Using autonomous innovation as an entry point for an adaptive capacity perspective, and smooth translation of local knowledge into wider policy channels such as the NAPA.

One of the assumptions behind promoting insurance products to small holder farmers has been that it can unleash demand for risky productivity-enhancing inputs. To test whether the availability of weather-based index insurance interlinked with credit can increase the demand for fertiliser use McIntosh Saris and Papadopoulos (2013) conducted a randomised control trial in the Amhara region of Ethiopia. Their study confirmed the theory that risk aversion, the experience of drought in the previous year, and credit constraint factors negatively affected the demand for fertiliser. However, they failed to find any evidence that insurance triggered a 'transformative' increase in input use for all farmers. Instead they found that existing high levels of fertiliser use was a strong determinant of insurance uptake, suggesting it primarily provided protection to those who already used fertiliser. Clarke et al (2012) have also argued that there is no convincing statistical evidence to suggest that weather index insurance reliably pays out on the years that are bad for smallholder farmers. Their analysis in an Indian state examining 9 years of matched weather and yield data for 318 weather index products revealed a negative correlation of -13% between area average yields and index claimed payments. Whilst they admitted that yield data was likely to be poor, this correlation was substantially lower than they were expecting. They suggested that first, catastrophic losses may have been caused by other perils (disease, etc) and localised weather events which were not captured by the weather index. Secondly, the weather index contract may not have been sensitive to the periods which matter most to farmers, such as the planting date. To deal with these types of challenges posed by index based instruments, innovative insurance products are in the process of being developed; such as the use of multiple indices to minimise basis risk (see Box 5.3).

Box 5.3: Smarter approaches for insurance products: lessons from south America and India

Price hedging: Countries are exposed to significant risks when oil prices rise; particularly when this occurs simultaneously to the failure of indigenous hydro-power output and/or sudden increase in demand such that importing expensive oil becomes essential. Drought areas and significant rises in temperatures can place stress on energy schemes. Some South American countries are currently involved in index based insurance products that provide a hedge against such oil price shocks. Multiple indices can be used to trigger payments, including abnormal lack of precipitation (drought) and oil prices. The weather modelling requirements for such a scheme are considerable but can be done over a 2-3 year period of time. [Interpreted from discussion with World Bank 2013]

Weather data and satellite images: Weather data, while originally in the public-sector domain can now be provided by public and/or private sector actors. This includes weather stations to measure rainfall, temperature and wind speed. To complement India's weather service, for instance, private data providers including Weather Risk Management Service [WRMS] and National Collateral Management Services Limited [NCMS] are assisting in collecting weather data for a fee. NCMSL have installed 1,000 automated weather stations that produce real-time data used in the development of weather-index products. Similarly the DHAN foundation in India is installing solar powered rain gauges at a 5 Km interval to minimise basis risk in weather index insurance projects. These transmit rainfall data at 15 minute intervals via GPS to a centralised database. Satellite images are being similarly purchased to collect different weather related data. Satellites for instance are able to capture cloud density, which is useful for rainfall prediction. [Prashad 2011] Another approach is to use normalised differenced vegetation indexes [NDVI] which measure 'green-ness' from satellite images that correlates with weather phenomenon. Such an approach is being tested by ILRI in Kenya [interpreted from Smith A et al. 2012].

In summary, Africa's insurance market is substantially under-developed, and will continue to lag behind economic growth, even while urbanisation and climate change are creating conditions under which insurance could perhaps become more and more valuable to underpin sustained development. A new insurance paradigm will be required to address this problem: the traditional insurance tools developed 300 years ago in the early days of the Industrial Revolution are unlikely to meet the needs of Africans as is and are unlikely to support the growth of insurance markets at a pace that will effectively support economic prosperity.

Microinsurance and innovations around index-based weather insurance (see Box 5.3) may hold the most potential to form an increasingly large part of the African property/catastrophe insurance marketplace. While recent World Bank experience shows issues with implementation and scaling up of index based insurance instruments, the three main advantages of index based insurance are still relevant for the SSA context:

1. Rapid payouts can be achieved
2. The product can be lower cost (no adjusting and lower administration costs, as well as less uncertainty in risk analysis so lower loadings from re/insurer)
3. Simplicity in both contracts and general market 'infrastructure' prerequisites

Box 5.4: Move from index to indemnity insurance products on global catastrophe bond markets

This figure from Swiss Re (2012) shows that the first half of 2012 has witnessed a large increase in the amount of catastrophe bonds issue using indemnity triggers . The charts below show that in 2007 the most popular trigger for cat bonds was industry index, wi th 43%, followed by indemnity at 30%. However, in 2012 indemnity is the most used trigger with 57%. Primary insurers appear to be less willing to accept a level of basis risk. However, in African markets (although the relevance of Cat bonds remains to be e stablished) this global shift may not be material as parametric may still offer a more accessible form of markets for both clients and re/insurers, whilst indemnity will require a more complex system to operate.

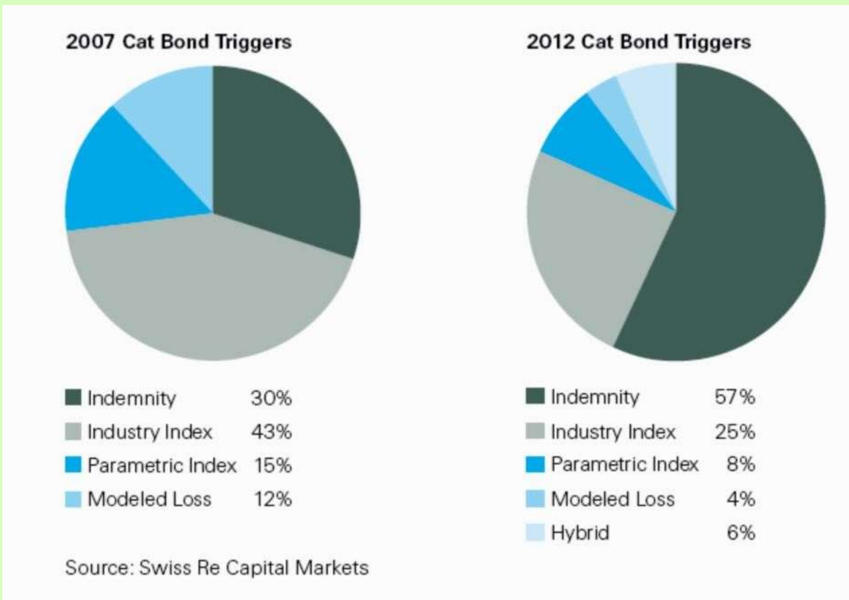


Figure 5.7 Global trends towards indemnity, Source Swiss Re (2012)

5.4 Summary of Current Insurance Availability in Africa

This section provides a brief synthesis and analysis of the information outlined in the compendium on insurance instruments identified for climate risks in the priority countries and beyond. For ease of discussion, we classified the instruments examined into four broad areas and sub-categories, generally following but somewhat expanding upon the basic categorisation outlined in a previous section, namely:

- Agriculture insurance Sovereign insurance instruments
    - o Crops o Lifelines
    - o Pastoral o Infrastructure
    - o Value chain o Other

- Traditional property/catastrophe insurance Weather/catastrophe microinsurance o Household o Index-based

- ○ Small Business ○ Social safety net
- ○ Other ○ Other

This classification system provided a quick method of categorising information as gathered. Table 5.1 provides an overview of the schemes in the compendium in terms of their general classification and the weather perils covered.

Insurance Type	Insurance Subtype	Flood	Storm	Drought
Agricultural	Crops	2, 7, **11**, **14**, **16**, **17**, 18, 24, 25, 26, 27, 28, 31, **37**, 42, **43**, **44**, **46**, **48**, 49	24, 25, 26, 27, 28, 29, **37**, 48	2, **11**, **12**, 13, **14**, 15, **17**, 18, 24, 25, 26, 27, 28, 29, 35, **37**, **39**, **40**, 42, **43**, 48, 49, 51, 52
	Pastoral	7, 25, 26, 28, **43**, **48**	25, 26, 28, **48**	8, 9, 22, 25, 26, 28, **43**, **48**
	Value Chain	20, 21, 23		20, 21, 23
	Other	**43**		35, **43**
Sovereign	Lifelines			6, **30**, 55
	Infrastructure	41	41	
	Other			
Traditional Property	Household	**1**, 47	**1**, 47	
	Small Business	**1**	**1**	
	Other	**1**	**1**	
Micro	Index-based	**16**, 18, 20, 21, 23, **31**, 42, 49		**5**, 8, 9, **11**, **12**, 13, **14**, 15, 18, 20, 21, 22, 23, 35, 42, 49, 51, **56**
	Social safety net	**17, 43**	29	**5**, 13, **14**, **17**, 29, **39**, **43**, **56**
	Other			

Table 5.1: Classification of schemes in the Compendium

Key: *The shading provides a qualitative view of the importance of a particular instrument for covering a particular peril, with red being most important and green least important. Font codes are as follows: red denotes schemes under development, blue denotes schemes in a pilot phase, bold black denotes operational schemes and regular black denotes schemes that have been discontinued.*

The geographical spread of these insurance instruments is illustrated in the following figures:

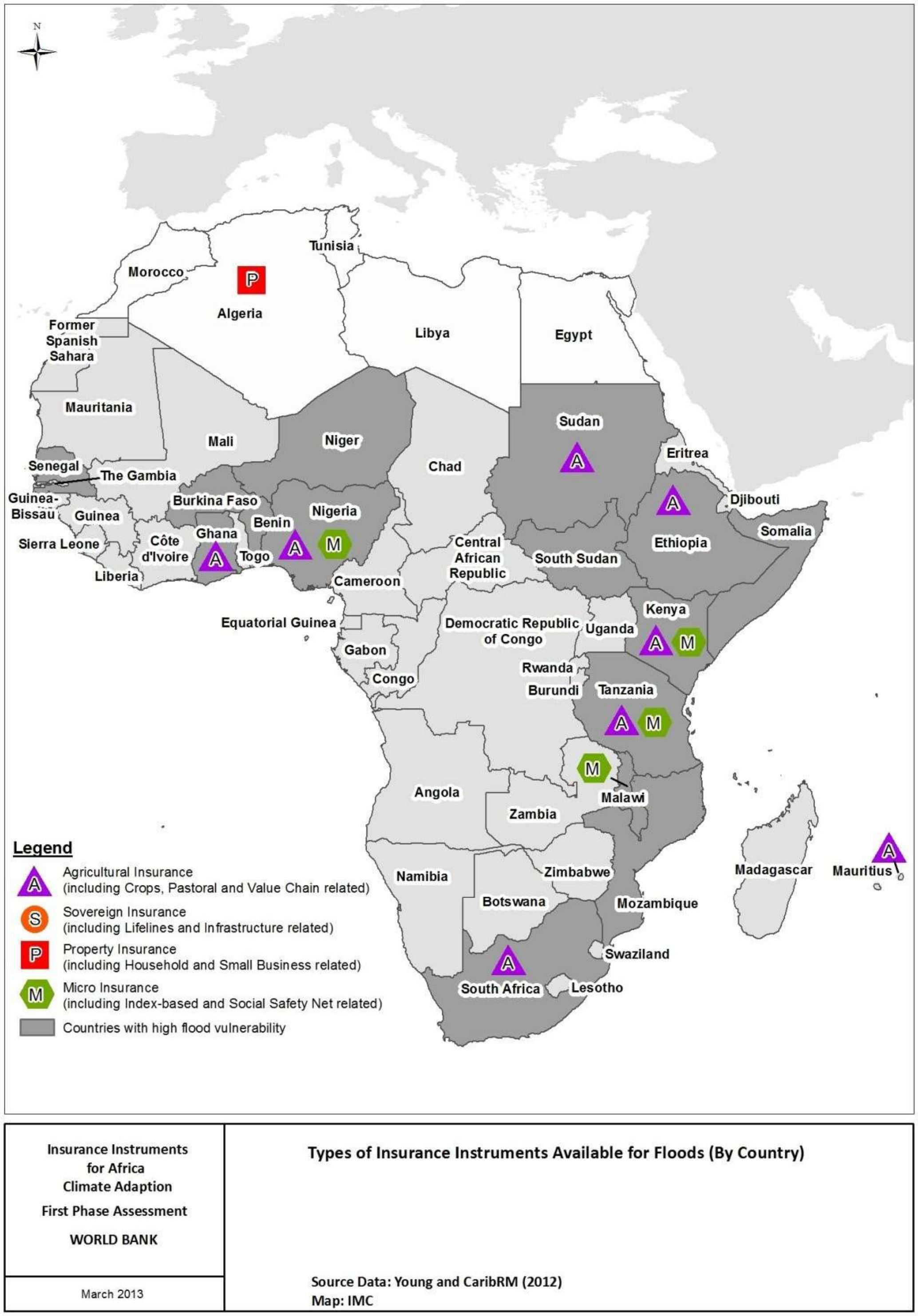


Figure 5.8: Spread of insurance instruments for flood risk in SSA, Source: IMC

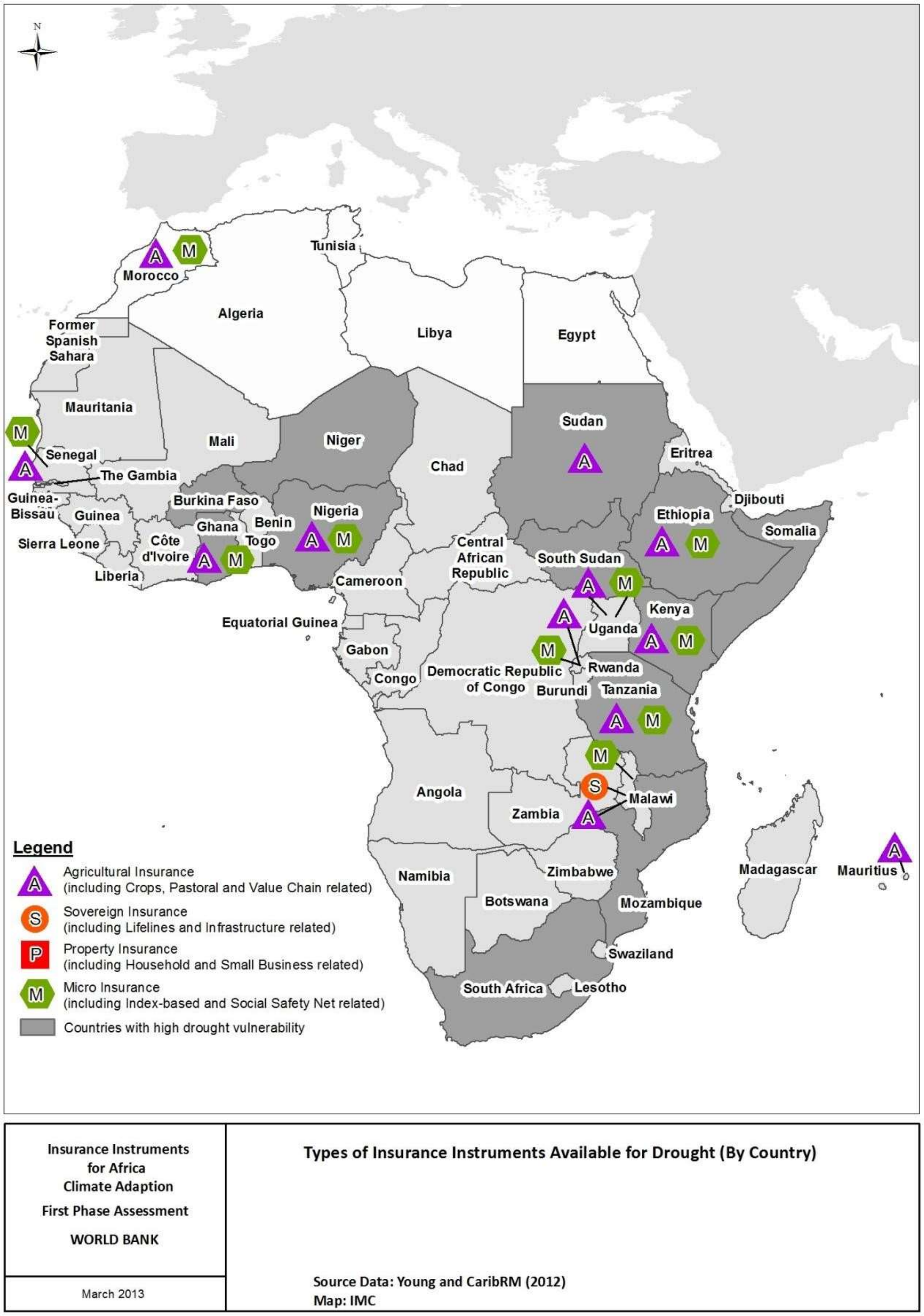


Figure 5.9 Spread of insurance instruments for drought risk in SSA, Source: IMC

Figure 5.10 Spread of insurance instruments for cyclone risk in SSA, Source: IMC

5.4.1 Insurance Need and Potential: Scoping Assessment in High-Risk Countries

Table 5.2 below presents indicator values for the nine priority countries, which can be considered as an estimate of the size of insurable risks and potential for introducing such instruments in high weather risk and vulnerable countries of Africa. The list of the indicators used, their definitions and sources of data, and rationale/explanation for consideration is provided in the table. We have considered five indicators that captures at the macro-level two key factors related to the insurable risks against climate hazards – *need* factors and *potential* factors. The *need* factors – which highlights the vulnerability and the magnitude of the risks faced by these countries – mainly cover two aspects: ecological and socioeconomic. The first indicator (and its adjusted corollary, in 1a below) provides an estimate of the economic value of the primary sector, i.e. agriculture and related practices which, in SSA, often face the most direct and harshest impact of changing climatic and weather hazards. Poverty, or the proportion of a country's population living below a minimum standard of living, is also an important component of the 'need' for risk financing – poverty rates are robust summary indicators of vulnerability to these hazards. However, given the close interaction of poverty levels with other aspects of livelihood which shapes socioeconomic vulnerability, the aggregate index we have provided earlier (index values are represented again for reference in the lower panel) can be considered as an appropriate indicator for overall vulnerability. Being mostly comprised of microeconomic indicators related to welfare aspects at the household as well as national levels, the aggregate index summarises both the intensity of vulnerability as well as the sensitivity of livelihoods to the shocks.

The other crucial dimension of national economies exposed to climate risks, and hence in need of insurance, is the infrastructural apparatus covering both civil infrastructure/public utilities such as transport, telecommunications, energy, etc. However, economic estimates of all aspects of a nation's infrastructure are extremely rare to obtain – the national account statistics only report 'value-added' to different industrial sectors. Here, we have attempted to approximate the value using a proxy – public spending on infrastructure, for which nationally comparable data is available. Although these figures are annual expenditures, and are a mix of both capital and recurrent spending, the figures provide an idea about (a standardised fraction/proportion of) national infrastructure. Although not done in the calculations below, these figures can also be adjusted for climate risk exposures.

Under the category of indicators denoting the 'potential' of insurance interventions the most crucial is the level of domestic saving, which are considered an excellent indicator of potential investment and capital formation opportunities. It can also be argued that the private, or household component, of gross domestic savings actually indicates the savings available at private households. These could be channelled into insurance products (purchasing and premiums) and represent an indirect proxy of the capacity to pay for insurance, a step before actual willingness to pay and the purchase such insurance products. However, it must be noted that the level of domestic savings can be notional and fail to provide an adequate summary of the economic capacity at the micro-level to afford the insurance products if income distribution is unequal and wealth (as well as surplus income) remains concentrated in the upper ranges of income distribution.

The last indicator, in the absence of nationally comparative estimates of government (public) social sector spending, is an approximation of the size, readiness and coverage of public-funded social security instruments. In the context of DRR and climate risk adaptation this is a key complement to the market-based climate insurance products. A country with higher expenditure levels on social security instruments and social protection in the wider sense can be expected to be more supportive and also have the required institutional framework to match with, or adapt to, the needs of climate risk insurance.

	Indicator	Domain/Explanation	Ethiopia	Kenya	Madagascar	Mozambique	Niger	Nigeria
1	Agriculture, livestock, hunting, forestry, fishing - Value (in billion US$)	This indicator provides an estimate of the 'size' of the primary economic sector at the highest climatic risk. The indicator, drawn from National Accounts statistics, is the share in national GDP	11.64	7.16	2.25	2.51	2.29	68.41
1a	*Adjusted value of (1) above*	*Since, the entire primary sector is not equally exposed to climatic risk, the above values are adjusted for proportion of the country's area facing 'climatic risk exposure' (See for indicator in last row)*	*5.53*	*3.34*	*0.92*	*1.16*	*0.98*	*29.20*
2	Total public sector spending on infrastructure (in million US$)	This indicator provides an approximation or proxy estimate of the economic value of national civil infrastructure (transport, energy, electricity, ICT)	1039.94	1246.81	279.12	289.92	114.13	2846.56
3	Gross Official Development Assistance (ODA) aid for disaster prevention & preparedness (current million US$)	This indicator provides an estimate of international development assistance/financing for DRR and climate risk adaptation. This may be considered as a proxy for the 'severity' of risks as well as 'capacity' of national governments to prove to be worthy/needful of such international support	5.14	1.84	1.69	4.2	4.36	0.324

4	Gross domestic savings (in billion US $)	Domestic savings formation is an important indicator of household investment capacities (as well as possible subsidies offered by governments), in order to subscribe to insurance products. A higher savings level indicates higher *potential* for introducing climate-risk insurance instruments	1.822	2.660	0.509	0.890	0.310	N.A.

5	Public social security expenditure (*excluding health expenditure*) in millions US $	If one consider the reciprocal, or complimentary role (compared to private insurance) of national governments in supporting climate risk adaptations via insurance instruments, an estimate of the *willingness* as well as *ability* of government can be guessed from its size of social sector expenditures. In the absence of detailed country-level budgetary data, this indicator of social security spending is a reasonable approximation.	979.63	4.50	14.89	49.67	18.23	N.A.

Supporting Indicators:

A	Index of socioeconomic vulnerability	These values may be used to adjust quantities for indicators (3) and (4), for effects of socioeconomic vulnerability intensities.	0.709	0.260	0.699	0.683	0.724	0.785	0.621	0.615	0.51
B	Proportion of territory exposed to climatic risks	This value has been used to adjust the value of agriculture (and other primary sector activities that are supposed to be most affected by climate risks).	47.51%	39.01%	46.72%	40.74%	46.22%	42.57%	42.68%	48.49%	39.79%

Table 5.2: Scoping assessment in high weather risk countries, Source: IMC

Box 5.5: Spatial Variation

In view of the large size of the countries being considered in the study, it will be essential to take spatial variability into account. It is unlikely for a single set of guidelines and thresholds to be relevant over the geographic diversity that exists, and in many cases, significant differences in climate will generate different hazards. It will therefore be important to provide a full climate characterisation of a given country. The characterisation may also be linked to topography and land use and thus provide additional focus on potential risks; such as drought related to particular crops and phenomena such as flash-floods. In countries with no or very few sources of currently accessible information, such as Cote d'Ivoire, Niger, Sierra Leone and Nigeria, climate characterisation and estimation of extremes will have to utilise historic sources or modelled data.

Addendum to Table 5.2: The following table further elaborates the sub-national characteristics for both weather data infrastructure and weather characteristics.

Country	Indicator	Domain/Explanation
	General data availability as reference stations from WMO country links*.	***This indicator summarises the main seasonal characteristics of weather and climate in each country and identifies related potential risks for insurance instruments.***
Ethiopia	6 stations. More station data available through NMS website www.ethiomet.gov.et	Tropical climate: single wet season in most of country. Rainfall total and intensity enhanced by relief: risk of flash flooding, landslides. Dry season rains may fail. East has drier conditions, and 2 wet seasons separated by dry seasons: drought risk.
Kenya	13 stations. A wide range of forecast and product services, website www.meteo.go.ke. Divided into 6 forecast regions.	Tropical with 2 wet and one long and one short dry (transitional) season. Rainfall totals and intensity affected by altitude. Risk of flooding, flash floods and landslips: drought if rains fail. Rainfall totals less in east; longer dry seasons. Risk of regular and sometimes prolonged drought.
Madagascar	6 stations. No forward link to NMS website	Most of island has a tropical climate with one significant wet season (monsoonal). Rainfall totals and intensity affected by altitude: risk of flooding, flash floods and landslips. Tropical storms and monsoon depressions bring risk of coastal flooding and storm damage. SW of island in 'rain-shadow' area: rainfall much less and risk of drought if rains weak.
Mozambique	11 stations. Forecast products, but some, e.g. radar not active. NMS link at www.inam.gov.mz. In Portuguese.	Tropical climate with one significant wet season resulting from southward movement of ITCZ. Rainfall total and intensity tends to decrease inland. Local and major basin flooding e.g. Zambezi, Limpopo. Lack of rain in dry season leads to local or widespread drought. Coastal area subject to cyclones/tropical with extensive flooding and storm damage.
Niger	1 station, for capital city, Niamey, only. No forward link to NMS website.	Niamey in west of country has a tropical/Sahelian climate. Single short wet season can bring storms and flash flooding. Prolonged dry season may be rainless in part: drought frequent and occasionally severe. Northern parts of country semi-arid: receive less rain and longer drought.
Nigeria	3 stations, none in northern half of country. No forward link to NMS website.	The country lies within 3 climatic zones: equatorial, tropical with 1 or 2 wet seasons (dependent on distance north of the equator, and semi desert, with a prolonged dry season. Equatorial and tropical zones are at risk of flooding: with major rivers in country, e.g. Niger, Benue, risks of major wide scale flooding exist. Major cities like Lagos and Ibadan have urban flooding problems. Northern tropical and semi-arid zones in Sahel are prone to drought.

Source: IMC

* The link to country data is through < http://worldweather.wmo.int/>. Weather and data links are provided by numerous other websites, e.g. NOAA, WeatherCast, World Weather and Climate Information, which may provide other national and location data.

5.4.2 General Findings

a) **A first preliminary conclusion based on the information gathered is the fact that there is very low availability and thus penetration of insurance instruments specifically for climate risks in the priority Sub-Saharan countries identified under this project.** Africa's share of the world insurance business has stayed within the narrow range of 1.1%-1.3% over an extended period of time even while the economies have grown. In 2009, Africa generated about US$52 billion out of a global insurance income of US$4,069 billion. The South African market accounted for 73% of the continent's premium income (Africa Re, 2011). This number is further reduced in the context of insurance instruments for climate risks and is further reinforced by a situation in which there is a general absence of large-scale business in most of the priority countries.

b) **Among the limited climate risk insurance instruments identified, there is a particular prevalence of agricultural insurance instruments specifically for drought and rainfall.** Further examination of the data reveals that most of these initiatives are for crop insurance schemes and more specifically index-based instruments. Although traditional agricultural insurance is available in some countries, it is generally very limited in scope and availability. A major lesson drawn by the World Bank and others from these pilot weather index insurance programmes over the past several years is that applying index-based insurance works most effectively at the meso rather than directly at the micro-level. Thus aggregators of risk, either specifically for insurance purposes or formed for other purposes, are a critical element of the value chain for weather index insurance.

c) **Most of the identified agricultural insurance instruments are part of pilot programmes with some form of international public sector involvement** and are generally subsidised by the Federal or state Government or by an international public agency or non-governmental organisation. Most of these programmes are also generally in place for an average of approximately 3 years.

d) **Microinsurance is an area where there has been significant growth over the last decade;** however, the vast majority of this growth has been in the life and health lines (MicroInsurance Centre, 2012). It is becoming clear, though, that further development of weather catastrophe microinsurance is important as a bottom-up approach to managing climate risk, and there is some evidence (e.g. Malawi) that top-down, sovereign-focussed approaches may not be sustainable in the absence of bottom-up awareness of and contribution to weather risk management.

e) **There is limited information on sovereign initiatives or property catastrophe markets outside of South Africa.** According to Steve Kyrematen (Activa Insurance, Ghana) the reason for this might be linked to the fact that most of the countries are 'characterised by non-representation of substantial assets in recognised formats such that their financial value could be capitalised'. He further states that 'In effect, such potential assets remain outside the scope of insurance and the owners of such assets being the majority of Africans remain without insurance on their assets. Conversely African insurers are practically barred from covering such risks and must contend with providing insurance for only assets in the formal sector'.

f) **The literature suggests that the demand for property damage and liability insurance by industrial/commercial concerns in the formal sector is influenced by need and potential benefits based on clients' information and knowledge.** Financial and accounting management considerations underpin demand such that large and medium-sized companies who may have borrowed to finance their operations are compelled to protect their material assets and exposure to liability as a condition for lending by commercial and investment banks, e.g. the Agriculture Credit Guarantee Scheme (ACGFS) operated by the Central Bank of Nigeria making it mandatory for farmers obtaining loans through the ACGFS to insure their farms under the Nigeria Agriculture Insurance Scheme (NAIS).

g) Demand may be influenced by the available range of insurance products. Certain niche and non-traditional products such as agricultural insurance, microinsurance and natural catastrophe covers have historically been given little focus in Africa compared to, say, Southeast Asia. This is in contrast to other lines of the insurance business such as health insurance where, for example, Ghana's National Health Insurance Scheme (NHIS) has achieved almost 60% coverage of the population whereas not more than 1.4% of the population in general have other forms of formal insurance.

h) Increasingly insurers are embracing modern and alternative distribution models that are able to connect insurers with potential clients in a reliable, cost-effective manner. This is particularly prevalent under the index insurance pilot programmes and some of the major innovations in the application of mobile money technology to insurance are being tested in Africa.

5.5 Areas of Challenge and Potential for Growth[42]

The findings from a review of existing schemes documented in Sub-Saharan Africa are generally in line with the findings from the World Bank publication released in November 2012 on Disaster Risk Financing and Insurance in Sub- Saharan Africa: Review and Options for Consideration. They can be summarised as follows:

1. ***Challenges on both the supply and demand side must be overcome to increase catastrophe risk insurance penetration in Sub-Saharan Africa.*** The lack of demand for products has been a key inhibiting factor in the increased uptake of catastrophe risk insurance. This can be attributed to multiple factors including: issues with product suitability; lack of understanding of products and a perception of product complexity; limited trust in institutions offering insurance products; and the absence of a "culture of insurance". On the supply side, challenges arise from sources such as inadequacies in data required for the development, pricing and accumulation management of products and the limited technical and financial capacity of domestic insurers to underwrite catastrophe risks.

2. ***Affordability of products poses a significant challenge to insurance uptake, although product simplicity and anticipated speed of payout are also cited as important considerations by consumers.*** For some consumer segments in Sub-Saharan Africa, standard catastrophe risk insurance products available through the commercial markets will meet their needs. However, for the majority of potential consumers, the affordability of insurance presents a problem; diverting limited financial resources to pay insurance premiums carries a high opportunity cost for low-income households. A number of models have been tested to reduce the cost of cover in Sub-Saharan Africa, with varying degrees of success. These include initiatives that aim to reduce operating costs (such as index linked products that reduce monitoring costs or the use of alternative networks to bring down distribution costs) and initiatives that cede part of the cost of cover to governments and donors (such as premium subsidies see Box 5.6).

[42] This section largely taken from the World Bank Publication on Disaster Risk Financing and Insurance in Sub-Saharan Africa: Review and Options for Consideration. World Bank. November 2012.

Box 5.6: Premium subsidies in agricultural insurance

Agricultural insurance has a long tradition of government support through premium subsidies. In 2007 the total public cost of agricultural insurance programs worldwide was estimated at 68% of global premium volume, with premium subsidies for agricultural insurance being offered in almost two-thirds of countries surveyed by a 2008 World Bank survey. However, incidences of government support to agricultural insurance are not as common amongst low-income countries.

Nigeria, Senegal and Sudan all have national agricultural schemes featuring high levels of subsidy; government subsidies through national agricultural insurers account for around 50% of gross premiums for most classes of agricultural insurance.

It should be noted that whilst premium subsidies support some of the largest agricultural insurance schemes worldwide (e.g. the US and India), they are not a prerequisite for high agricultural insurance penetration and have not had universal success. A number of countries have achieved high agricultural insurance penetration without subsidy, such as Germany, Argentina and Australia.

Source: Disaster Risk Financing and Insurance in Sub-Saharan Africa: Review and Options for Consideration. World Bank. November 2012.

In 2010, the Microinsurance Innovation Facility estimated a potential $25 billion market in Africa for microinsurance, covering a potential consumer base of 700 million people[43]. Within the range of microinsurance products, those products providing catastrophe risk cover (agricultural insurance and property insurance) are estimated by the Facility to have a potential consumer base of 165 million in Africa.

3. ***The development of catastrophe risk insurance markets for non-poor households and the commercial sector will indirectly benefit the most vulnerable households by liberating government and donor resources.*** In helping to ensure business continuity and reducing the pool of households requiring financial aid post-disaster, the burden on government and donor resources is reduced, freeing up funds to target the poor. There are a number of ways in which governments can support the growth of their domestic insurance markets. Some of these are discussed in the following section.

4. ***Difficulties of product distribution are exacerbated by the high proportion of the population that is financially excluded and living in difficult to reach rural areas.*** Sub-Saharan Africa has the largest proportion of financial exclusion of any region worldwide - only 12%[44] of the population of Sub-Saharan Africa has access to a bank account. With the majority of the population living in rural areas, disconnected from financial services infrastructure, distribution of all financial services including insurance, poses a significant challenge.

5. ***A number of non-traditional distribution channels have been tried as a way to increase access to insurance in Africa, including social safety nets (see HARITA box 4.6) and mobile phone networks with varying degrees of success.*** The productive safety net program in Ethiopia has been used to reach more than 13,000 farmers with weather index insurance.

[43] Source: Government Support to Agricultural Insurance, Mahul and Stutley.

[44] Market size based on definition of target consumers for microinsurance as the working poor, and the vulnerable nonpoor. $25 billion market size extrapolated from the assumption of potential insurance expenditure at 5% of GDP.

Mobile phone networks were being used to deliver insurance (principally life and health covers as opposed to catastrophe risk) as part of pilots or live schemes in at least eleven SubSaharan African countries as of 2011. The networks of banking institutions – particularly agricultural banks and microcredit institutions – have also been leveraged to try and reach the rural poor with insurance products, although the high levels of financial exclusion have limited the outreach of these networks. Informal financial networks, such as community savings and loans groups have significant potential as distribution channels and merit further investigation as a way to provide catastrophe risk insurance in Sub-Saharan Africa.

6. ***Many domestic insurers in Sub-Saharan Africa lack the technical capacity to underwrite catastrophe risk.*** Many domestic insurers in Sub-Saharan Africa have limited experience in offering products that cover catastrophe risk, and therefore often lack the technical expertise required to develop, price and market these products. However, the growing presence of international reinsurers in the region, and recent initiatives to bring external product expertise into less developed markets, have begun to address these issues by connecting domestic insurers with a broader pool of expertise.

7. ***Lack of information also presents a challenge. It is difficult for insurers to develop and price insurance products for regions where no data is available to indicate the magnitude and type of potential losses that could be sustained under the policies.*** This data is simply not available for large parts of Sub-Saharan Africa where loss records do not exist, vulnerability is poorly understood, and infrastructure to capture hazard levels (e.g. networks of weather stations) is sparse or not fully mobilised.

8. ***Experience shows that public-private partnerships may be an effective approach to establish sustainable and affordable catastrophe risk insurance programs.*** Governments can establish an enabling environment with a supportive legal and regulatory framework, for example, by setting requirements for premiums to reflect risk (where appropriate) and by adequately supervising insurers' solvency. The provision of basic risk market infrastructure as public goods also catalyses growth, building domestic insurers' capacity while supporting the sale of reliable, cost-efficient insurance products. The government can also facilitate catastrophe risk pooling mechanisms that help local insurers aggregate and structure risks and transfer them to the international reinsurance market. In order to reduce uncertainty for insurers and insured, governments may also want to consider providing a sovereign guarantee as reinsurer of last resort for only the most catastrophic losses, while at the same time clearly delineating its contingent liability for private losses.

5.6 Assets/Sectors and Investments of Interest

Given the general insurance landscape outlined above and the areas of challenge and potential for growth coupled with discussion with the World Bank, we have identified six areas of development programming in Africa which are impacted by climate change and for which investment in insurance tools could play an important role in adaptation. While many of the documented schemes presented in the preceding sections cover some of the areas listed below, there is abundant room for innovation both within current schemes and programmes and through new initiatives.

The country fact sheets developed for this project include snapshots of the focus of development investment in Sub-Saharan Africa (See Appendix 7.1). These highlight the oversized role of major infrastructure and green energy projects, and also show that climate change, through both mitigation

and adaptation programming, is already a key driver of investment and is likely to be increasingly so in the foreseeable future.
The potential tools are summarised as follows:

- Sovereign risk transfer instruments, which can support comprehensive national disaster management, and associated investment in data collection and risk assessment;
- Weather index insurance for agriculture (including hybrid schemes building on conditional safety net principles and evolving to insurance);
- Traditional and/or innovative tools for managing flood risk in rapidly urbanising cities, aligned with urban land use planning activities;
- Insurance products for MSMEs to protect against catastrophe weather impacts (and thereby manage revenue/expense volatility), likely linked to credit availability;
- Building a regional weather derivatives market focussed on water supply hedging for major green energy (hydro-electric) schemes (but which could also cover demand-side hedging tools);
- Weather risk hedging and insurance to accompany major infrastructure development and climate change adaptation projects (roads, bridges, lifelines etc, which might also be part of weather derivatives market).

Further investigation of these ideas is provided below.

5.6.1 Sovereign Risk Assessment and Financing

A recent World Bank discussion paper (World Bank 2012b) provides a comprehensive review of sovereign-level disaster risk financing options including risk transfer in the Sub-Saharan Africa context. In addition to exploring the use of insurance tools, governments must play a leading role in generating public goods to drive an increased understanding of risk, primarily to support their own comprehensive disaster management strategies, but with the spin-off benefit of facilitating insurance market development. Risk assessment includes the gathering of real-time and historical hazard and impact/loss data as well as the derivation of hazard and risk maps to inform disaster preparedness, and contingency and development planning.

Sovereign facilitation of traditional market development is multifaceted; development of a robust but flexible regulatory regime can foster insurance market innovation, while use of domestic markets by the Government (as a major economic engine) can drive premium and capacity growth. This then provides not only liquidity and substantial inflow of capital after major events, but also generates investment in growth (as insurance companies put their assets to work).

5.6.2 Weather Index Insurance for Agriculture

Weather index insurance for the agricultural sector is the most active area of insurance innovation for climate change adaptation across Africa. The current high exposure of the agricultural sector to weather extremes is likely to be exacerbated by climate change and, when allied with the continued need for expansion and increased efficiency within the sector, the case for increasing access to insurance becomes compelling. However, traditional indemnity crop insurance is an expensive proposition, heavily subsidised throughout the developed world and not a model that Sub-Saharan Africa is bent on following. Instead, innovations around index-based weather insurance offer a potential solution, significantly reducing development and administrative costs while addressing the key risks to agricultural production. With informal savings and loan mechanisms widely used in SubSaharan African countries to manage the impact of unexpected shocks on income and assets, most success is likely to be achieved in building from rather than crowding out these mechanisms.

As documented within the insurance scheme compendium, there are many pilot schemes investigating mechanisms for index-based weather insurance across the continent. Many have had successes, but few have demonstrated the ability to scale up to the degree necessary to have the broader impact that many practitioners believe possible. Cole et al. (2012) provide the most recent review of the quantitative impacts of weather index insurance on smallholder farmers; they find that:

- Several non-price factors including financial literacy, trust and liquidity appear to affect demand for index-based micro-insurance products

In terms of exploring continued innovation in this sector, Cole et al (2012) recommend that:

- Piloting group-based micro-insurance products, which have the potential to ease both informational and liquidity constraints, might increase take-up rates;
- Combining the roll-out of insurance products with agricultural extension programmes and financial literacy training is likely to increase both take-up and impact of products sold; and
- In terms of research implications, the review has revealed substantial evidence gaps in the literature on take-up and impact of index-based micro-insurance.

Another cross-cutting avenue for innovation may be to mix contingent safety-net and insurance mechanisms to build a hybrid programme which utilises the tools of index insurance but operates as a contingent cash transfer scheme in its early years; this would engender support and provide a period of lesson-learning for all parties. If linked to investment in extension activities focussed on adaptation and risk reduction, the convergence of reduced risk and enhanced understanding could be key components of enabling a sustainable insurance mechanism to be founded.

5.6.3 Urban Flood Insurance

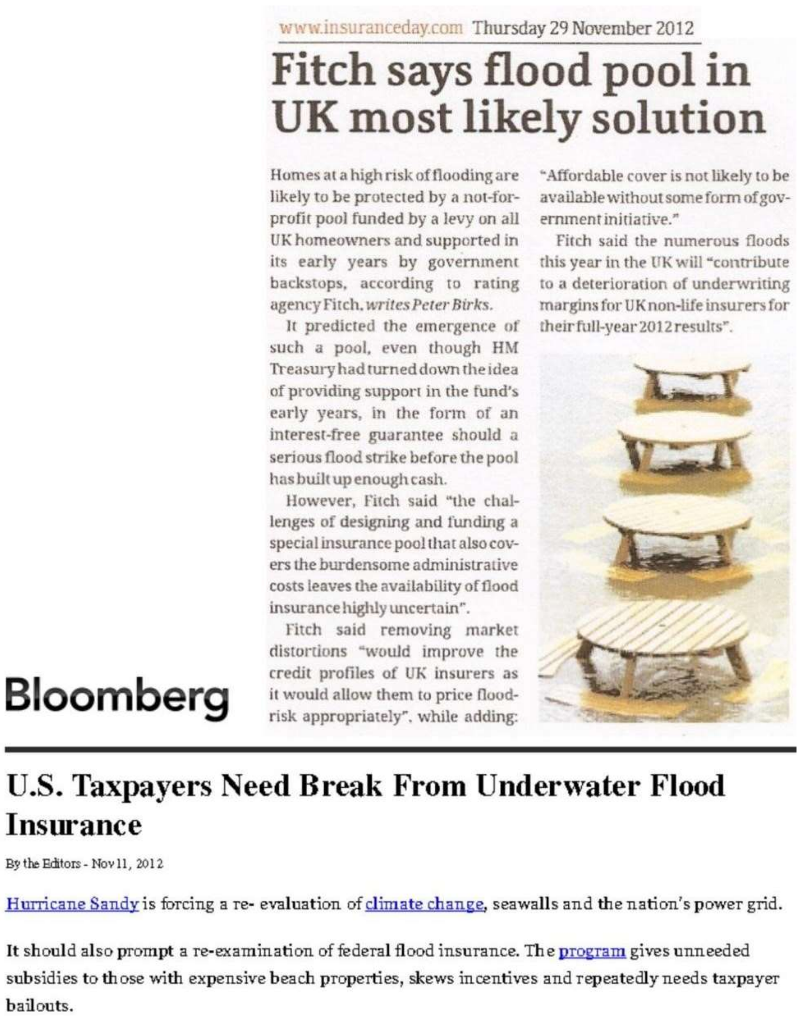
While lack of rainfall tends to be the main hazard in rural areas of Africa, too much rain will have an increasingly dramatic effect in causing loss and damage in the rapidly-growing urban areas which centre on the region's main cities. Urban flood risk is recognised globally as a major source of economic damage, and rapidly urbanising areas in the developing world are particularly prone to flood impacts due to the lack of adequate land-use planning, the high value of the flat areas of bigriver flood plains, and the destruction of natural flood defences. Coastal cities will be additionally impacted by rising sea levels and, in several cities in Africa, the threat of coastal flooding from more severe Tropical Cyclone storm surges.

Douglas et al (2008) provide an excellent overview of urban flood risk in Africa. They conclude that:

- Urban flooding is becoming an increasingly severe and more frequent problem for the urban poor;
- Climate change is altering rainfall patterns, tending to increase storm frequency and intensity, thus increasing the potential for floods;
- Local human factors, especially urban growth, the occupation of floodplains and the lack of attention to waste management and to the construction and maintenance of drainage channels are also aggravating the flooding problem. Particularly problematic is the unwillingness of government at all levels to engage in the provision of integrated drainage systems in informal settlements, which are often regarded as being outside accepted urban regulation and planning systems.

Managing urban flood risk is a major challenge, and both traditional and innovative insurance mechanisms can play a role in mitigating the impacts of flooding. Traditional flood insurance schemes in the developed world are often separate to other property/catastrophe insurance programmes, or are at least partly financed by the state. The conflict between developing prime real-estate and securing adequate insurance at a viable price is one which rages in many countries (Figure 5.11).

Traditional indemnity insurance, particularly where risk-based pricing is not possible, tends to reward (or at least not penalise) development in flood-prone areas. This not only increases risk for those situated in those unsuitable areas but also those downstream, as urbanisation increases the volume and pace of run-off which combine to increase the likelihood and magnitude of flood events for a given amount of rainfall.



www.insuranceday.com Thursday 29 November 2012

Fitch says flood pool in UK most likely solution

Homes at a high risk of flooding are likely to be protected by a not-for-profit pool funded by a levy on all UK homeowners and supported in its early years by government backstops, according to rating agency Fitch, *writes Peter Birks.*

It predicted the emergence of such a pool, even though HM Treasury had turned down the idea of providing support in the fund's early years, in the form of an interest-free guarantee should a serious flood strike before the pool has built up enough cash.

However, Fitch said "the challenges of designing and funding a special insurance pool that also covers the burdensome administrative costs leaves the availability of flood insurance highly uncertain".

Fitch said removing market distortions "would improve the credit profiles of UK insurers as it would allow them to price flood-risk appropriately", while adding: "Affordable cover is not likely to be available without some form of government initiative."

Fitch said the numerous floods this year in the UK will "contribute to a deterioration of underwriting margins for UK non-life insurers for their full-year 2012 results".

Bloomberg

U.S. Taxpayers Need Break From Underwater Flood Insurance

By the Editors - Nov 11, 2012

Hurricane Sandy is forcing a re- evaluation of climate change, seawalls and the nation's power grid.

It should also prompt a re-examination of federal flood insurance. The program gives unneeded subsidies to those with expensive beach properties, skews incentives and repeatedly needs taxpayer bailouts.

Figure 5.11: Challenges to flood risk management; recent news from the United Kingdom and the United States highlighting current discussions to overhaul existing mechanisms

Creative use of traditional insurance, where risk-based pricing drives development into lower-risk areas, can certainly offer solutions. But innovations using index-based tools may also be appropriate in some settings, with triggers based on rainfall or river flow rates helping to offset the impact of flood events. Use of the insurance industry's expertise in risk analysis will also be critical in adequately mapping flood risk and ensuring that urban planning fully incorporates flood risk management.

5.6.4 Weather Catastrophe Insurance for MSMEs

In many sectors of developing world economies, growth is driven by micro, small and medium enterprises. Even in the developed world, small businesses do not always participate in the insurance marketplace, and MSMEs in the developing world do not generally have many insurance tools at their disposal to help offset the impacts of severe weather on their own assets and operations or those of their suppliers or markets. MSMEs forming part of the agriculture and tourism value chains are particularly exposed to weather risk, and the development and implementation of specific tools for MSMEs to better manage their risks are likely to be very important in supporting sustained economic development across much of Africa.

In addition to developing insurance tools specifically designed to meet the needs of MSMEs, innovative distribution mechanisms must be explored to help reduce the frictional costs of insurance delivery. The use of group coverage for multiple MSMEs can leverage other associations built on shared financial service requirements and can also form a strong basis for building capacity in understanding and implementing risk management including risk reduction.

5.6.5 Development of a Weather Derivatives Market

Hydro-electric power (HEP) development is one of the largest areas of investment in Sub-Saharan Africa, as the continent builds towards underpinning its growth with green energy sources. Stable energy supply and pricing is critical to sustained economic development, and a significant risk to attaining these goals in the case of HEP is the supply of fuel, *i.e.* water. Insurance or hedging tools to manage this risk might provide a substantial economic value for individual and pooled HEP schemes.

In Europe and particularly North America, the energy supply sector has been the primary driver of a vibrant weather derivatives marketplace, generally using these tools to hedge against particularly high or low temperatures, both of which drive up demand and require additional generating capacity. For HEP schemes, it is mainly the supply side which can benefit from weather derivatives in the short term, which would then play an equivalent role to fuel price hedging by non-renewable electricity producers.

However, in the longer term, a market for demand-side hedging instruments may also develop as economic development and urbanisation bring more and more people into an environment where excessive temperature variation will be managed through greater use of artificial cooling and heating. Such demand variability is managed in North America in particular through the use of derivatives on high/low temperature measurements.

5.6.6 Insurance for Infrastructure Development and Climate Change Adaptation

Sovereign governments throughout Africa are managing infrastructure development at an unprecedented rate, a portion of which is related directly to climate change adaptation. As previously highlighted, they have many options in developing a risk financing strategy that not only accounts for current risks but also addresses future risks resulting from a harsher climate and with greater exposure due to economic development.

Many projects, particularly lifeline and urban infrastructure development, have some element of risk to the natural environment. Flood and, in coastal areas of southern Africa, storm surge, are the two major hazards which require quantification and management within any infrastructure development project. While future climate change and its influence on, say, the return period of a certain design flood, can be incorporated into project design, there is often sufficient uncertainty and insufficient time to fully understand and incorporate the potential consequences of hazard events several decades into the future. While insuring individual roads or bridges may not be feasible or economically viable, identification and management of the added ongoing liability resulting from infrastructure development is critical to ensure the lasting legacy required of such major investments.

For climate change adaptation investments, there is a particular need for insurance mechanisms to provide bridging protection in case major events occur before completion of the adaptation mechanism or as a long-term solution to managing future risk from greater-than expected climate variability.

5.7 Recommendations

Building on the findings based on a review of existing insurance programmes and initiatives in SubSaharan Africa and the world on the World Bank on Disaster Risk Financing and Insurance in SubSaharan Africa (November 2012), the following recommendations are made for consideration.

Recommendation 1: 'Insurance client briefs' for shortlisted countries including a client value strategy: Mapping client priorities and opportunities to integrate widely with other risk management processes in SSA such as adaptation.

Insurance in the case of SSA is in its infancy and particularly in the current harsh global economic climate demonstrating the potential for 'client value' is key. The starting process for this will to carry out more in-depth work in the priority countries on the type of products (by each type of client farmers, businesses, municipalities/sub-national governments, government budget managers] that have the potential to provide substantial 'client value' as against other risk financing options. It will also be useful to consult and identify opportunities for insurance to work alongside wider projects that are enhancing disaster management as well as the adaptive capacity of the people, institutions, services and infrastructure [Some initial ideas are presented in Chapter 6]. For African markets understanding where in the socio-economic set up insurance can make a difference is vital before insurance is confirmed. It will not be amiss to prepare a client requirements brief as part of the insurance design of each country, particularly because Africa has such a substantial urbanising and informal sector.

Increasing urbanisation and growth in both formal and informal sectors means insurance companies will need to understand the requirements of potential clients more closely in the process of developing suitable products. Source: Ripin Kalra

Recommendation 2: Development of risk information and modelling systems to assess the economic and fiscal impacts of natural disasters

Despite the large number of risk assessment initiatives that have been rolled-out on the continent, the integration of risk information into DRM decision-making is extremely limited. This is due to a number of reasons including the absence of information, lack of standardisation (which makes existing datasets difficult to use), lack of understanding of the data and its potential value and the absence of data stewardship. Options to promote wider and better use of risk information include:

- Development of catastrophe risk models that articulate disaster risk in terms of ultimate impacts (e.g. direct financial and broader economic losses). This would require development of exposure datasets detailing assets, livelihoods and population at risk, and models of the vulnerability of these exposures to the prevailing physical hazards. Partnerships with the private sector and academia could be considered as one method to develop models and technical capacity in this field whilst maintaining local ownership;
- Investment in infrastructure to monitor and record hazards to support risk assessment, and potentially, index-linked insurance products;
- Fiscal disaster risk analyses for governments to quantify the contingent liability of the State arising from natural hazards;
- Development of policies and capacity-building initiatives to mainstream disaster risk information into decision-making processes within government institutions with DRM responsibilities. This specifically includes the integration of disaster risk information into fiscal and public debt management; and
- Development of national or regional platforms to consolidate and standardise risk information.

Recommendation 3: Development and implementation of disaster risk financing and insurance strategies for governments

Over-dependence on external aid post-disaster is inhibiting development in the region. As demonstrated by the recent drought in the Horn of Africa, the current systems in place to help governments meet the cost of disasters are not adequate and can result in significant delays in response and recovery. A number of options are presented below to promote better management of the impact of disasters at the fiscal level, based on the principal of layering of sovereign DRFI instruments in accordance with risk frequency and severity.

Governments should integrate natural disaster risks into fiscal risk assessment and management. Fiscal disaster risk analyses could be used to quantify the State's contingent liability and take a proactive approach to reducing budget volatility from disasters. Systems to track disaster-related public expenditure should also be established. Tracking systems are essential in order to effectively manage disaster response efforts, identify gaps in funding, support accountability, and draw lessons learned for potential improvements in disaster risk financing arrangements.

Countries should develop national strategies for financing the cost of disasters to the fiscal budget, matching appropriate instruments (retention, transfer) to layers of risk and specific perils (see box 5.7. for illustration from Mexico). These strategies should be tailored to the specific circumstances of countries including a country's level of income, the disaster risks faced, the scale and nature of public contingent liability, government fiscal capacity, and the level of access to international capital markets. This would allow governments to increase their financial response capacity in the aftermath of a disaster, allowing them to execute timely and effective responses. Such strategies could include action at the national and sub-national level (e.g. municipal/regional).

Box 5.7: Mexico's Natural Disaster Fund (FONDEN)

FONDEN, Mexico's Fund for Natural Disasters, was established in the late 1990s as a mechanism to support the rapid rehabilitation of federal and state infrastructure affected by adverse natural events. Created as a budget line in the budget law in 1996, it became operational in 1999. Funds from FONDEN's Program for Reconstruction can be used for the rehabilitation of (i) public infrastructure at the three levels of government (federal, state and municipal); (ii) low-incoming housing; and (iii) forestry, protected natural areas, rivers, and lagoons.

The FONDEN Program for Reconstruction is FONDEN's primary budget account, which is linked with the FONDEN Trust. The FONDEN Program for Reconstruction channels resources from the Federal Budget to specific reconstruction programs. In the aftermath of a disaster, funds

A "bottomcommitted to a specific reconstruction progra-up" disaster risk financing approach should bem will be transferred to a dedicated sub considered. Governments should first -account in secure financing for recurrent events (bottom risk layer) through risk retention (e.g. reserves and /or the FONDEN Trust for execution. contingent credit) and then move up to increase their levels of financial resilience through disaster risk transfeThe FONDEN Trust holds these resources until these programs are fully implemented. It also acts r instruments. Instruments such as insurance for public assets, or budget support to governments through mechanisms such as the Africa Risk Capacity project should then be considered as the contracting authority for market-based risk transfer mechanisms, including insurance and within this layered framework.catastrophe bonds.

Given the potential welfare benefits of pAs part of the Government of Mexico's effort to move toward a proactive approach to disaster ooling risk between sub-national units within a country, mechanisms for better allocation of resources within countries should be also a priority risk management and financing, another budget account, the FONDEN Program for Prevention, or consideration within a sovereign DRFI strategy.FOPREDEN, was established in the early 2000s. FOPREDEN promotes investment in risk reduction by funding (i) risk assessment, (ii) disaster risk reduction activities, and (iii) capacity building on

Recommendation disaster prevention. FOPREDEN requires states to complete a risk assessment (including ***4: Development of schemes to buffer the poorest households from disaster*** the ***shocks***development of a risk atlas) before being eligible for financing. Although resources for prevention remain significantly less than those for reconstruction, the GoM continues its effort to shift focus

For the poorest households, even microinsurance may not be a viable option due to cost. Therefore, and funding from ex post response to ex ante disaster risk management. development of other micro -level contingent financing schemes such as conditional safety net programs could be examined. CSource: 'FONDEN: Mexico's Natural Disaster Fund ontingent financing that is not market– A Review,' The World Bank and the Government of -based can still confer some of Mexico (2012).
the key benefits of insurance if structured carefully. These might include rapid payouts through the use of "hard trigger" such as weather or yield-based indices, or the promotion of risk reduction activities as demonstrated by the HARITA scheme.

As highlighted by a recent IFPRI study, strong welfare benefits can be derived from the establishment of safety net schemes and their subsequent use post-disaster. The pre-existence of distribution mechanisms that effectively target the poor is vital if the benefits of rapid liquidity through disaster risk financing instruments are to be fully realized.

Recommendation 5: Promotion of catastrophe risk insurance markets

Insurance penetration for those of lines of business covering catastrophe risk is extremely low in SubSaharan Africa. This can be attributed to issues on both the supply side (e.g. lack of infrastructure, unsuitable products) and the demand side (e.g. lack of awareness of the value of products, affordability issues). As noted above, suitability of products is a critical driver in the uptake, or lack of uptake for insurance products and a careful assessment is required of the needs of the consumer in order to determine what types of insurance product may be appropriate, and indeed whether insurance is the right tool when considered relative to other coping measures and options for investment.

A considerable amount of innovation has been applied to the problem of increasing access to insurance in Africa, with mixed success. A stock-taking exercise examining the successes and failures of catastrophe risk insurance pilots across the region would be a good starting point. Other options to increase access to and uptake of insurance for catastrophe risk include:

- Development of distribution channels for insurance to increase outreach. This could include investigation of alternative routes (such as the use of mobile phone networks to distribute insurance as described in the section on areas for potential growth, or use of informal community networks) or expansion of existing infrastructure;
- Development of public goods such as catastrophe risk models, standardised products, development of claims databases and other underwriting tools. These should aid the development of a cost-effective, affordable, and sustainable insurance markets. The Southeastern Europe and the Caucasus Catastrophe Risk Insurance Facility (SEEC CRIF) provides an interesting example of how governments and international donors can collaborate to create public or shared market goods for insurance (see Box 5.8);
- Support to financial literacy programs to increase awareness of the role and value of insurance;
- Creation of regulatory environments to promote expansion and sustainability of catastrophic insurance, supporting emerging products (such as microinsurance and index-linked insurance) and emerging providers, but also enforcing capital adequacy; and
- Investigation of the potential to create structures within markets to accelerate development such as public-private partnerships and risk pools. See box 5.9.

Box 5.8: The South Eastern Europe and the Caucasus Catastrophe Risk Insurance Facility (SEEC CRIF)

The South Eastern Europe and the Caucasus Catastrophe Risk Insurance Facility (SEEC CRIF) project is facilitating the development of national catastrophe and weather risk markets in SEEC through the design and introduction of innovative, low-cost insurance products, insurance business production technologies, regulatory reform, consumer education, and provision of reinsurance services. The project is a supported by the World Bank, UNISDR, the European Commission, the Swiss State Secretariat for Economic Affairs, and the Global Environment Facility.

SEEC CRIF is being implemented through the creation of a specialty government-owned catastrophe risk reinsurer, Europa Reinsurance Facility Ltd. (Europa Re), with the view to improving access to weather risk and catastrophe risk insurance for millions of households, small businesses, and governments in the Facility's member states. Established in 2009 in Switzerland, Europa Re employs an independent Board of Directors and is managed by a professional management team. SEEC member governments are Europa Re's shareholders; currently, Albania, the Former Yugoslav Republic of Macedonia, and Serbia have joined the Facility, with others in discussions to join. Operations are set to commence in September 2013.

Europa Re is currently completing probabilistic high resolution regional earthquake and flood risk models for the SEEC member countries. The models will be used for the purposes of underwriting and pricing flood and earthquake risk in these countries. It is also developing a web-based underwriting and risk pricing platform that will provide insurers with automated real-time underwriting, pricing, and reinsurance decisions for all risks assumed through the sales of approved catastrophe insurance products in member countries. This platform will allow participating insurers to keep track of all policies issued through the portal and will enable them to report, and Europa Re to settle, insurance claims. Finally, Europa Re will utilize the platform to track its risk accumulations by location and type of risk.

Source: World Bank and GFDRR, 2012. Advancing Disaster risk financing and insurance in ASEAN member states.

Box 5.9: Turkish Catastrophe Insurance Pool

Turkey provides an interesting example of a pooled homeowner's catastrophe insurance program to overcome problems of market failure in Turkey, namely a lack of local market earthquake capacity and low voluntary demand for earthquake insurance. By aggregating risks into one single insurance portfolio, insurers can approach the international reinsurance market with a larger, more diversified portfolio, which should lead to lower reinsurance prices and reduced transaction costs. By aggregating risks through a vehicle or facility, a single point of entry is created through which the international donor community and/or the government can inject financial and technical capacity to support the risk. This point of entry can be used to develop capacity of the domestic market to underwrite catastrophe risks while simultaneously protecting the domestic insurance market from the threat of insolvency due to large correlated losses.

The Turkish Catastrophe Insurance Pool (TCIP) is a public sector insurance company that is managed on technical and commercial insurance principles. The TCIP purchases commercial reinsurance and the Government of Turkey acts as a catastrophe reinsurer of last resort for claims arising out of an earthquake with a return period of greater than 300 years.

The TCIP policy is a stand-alone property earthquake policy with a maximum sum insured per policy of US$65,000, an average premium rate of US$46 per annum, and a 2% of sum insured deductible. Premium rates are based on construction type (two types) and property location (differentiating between five earthquake risk zones) and vary from less that 0.05% for a concrete reinforced house in a low risk zone to 0.6% for a house located in the highest risk zone. Since inception, TCIP has averaged a penetration rate of about 20% or 3 million domestic dwellings.

Source: World Bank and GFDRR, 2012. Advancing Disaster risk financing and insurance in ASEAN member states.

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Source: World Bank and GFDRR, 2012. Advancing Disaster risk financing and insurance in ASEAN member states.

5.8 DEVELOPMENTS IN WEATHER DATA SINCE 2013

5.8.1 Use of Satellite Derived Data

The Met Office has successfully used satellite derived rainfall data in studies in African countries since 2013. These include:

Rainfall return period analysis in Guinea

This study made use of TRMM data. The study included verification of the data against local observations. It concluded that the timing of rainfall events were not accurately captured by the satellite measurements. However, a comparison of the top 1% of gauge and TRMM measurement undertaken at each site, produced very favourable results. Several methods were employed to compare the high rainfalls (the top 1%);

- a visual comparison of high rainfalls ranked in order of magnitude and plotted on a line graph

- a visual comparison of the Cumulative Density Functions of high rainfalls
- application of the Kolmogorov-Smirnov statistical test to assess whether or not the high rainfall datasets were statistically different;

  and the calculation of the average bias between the high rainfall datasets.

A bias correction was applied to data at one location where consistent differences between observational and satellite data were found. The study concluded that the comparisons of TRMM and gauge data at all sites did not preclude the use of TRMM in the Extreme Value Analysis (EVA) and for the derivation the short period rainfall return level estimates.

The EVA was undertaken using all available gauge and TRMM measurements at each site. Return period values of 3, 12, 24, 48 and 72 hours durations with return periods of 1, 2, 10 and 100 years were calculated.

Rainfall return period analysis in Botswana

This study also made use of TRMM data. It also verified the TRMM data against rainfall observations. Comparisons of the climatology of gauge observations and TRMM at each site, lead to the following conclusions;

- TRMM correlates strongly with rain gauges when rainfall is aggregated over longer time periods such as months, years and seasons;
- TRMM correlates weakly over shorter time scales i.e. daily or sub-daily, but in the absence of rain gauge observations, this is the only dataset available for analysis;
- The timing of high rainfalls are not well represented by TRMM but again in the absence of other information an attempt has been to amalgamate observed daily rainfalls with TRMM timings.

Overall, the climatology of rainfall is generally well replicated by the TRMM measurements but the timing of rainfalls may be imprecise and extremes may be missed.

For the EVA based on thresholds only the top 1% of values are used. A comparison of the top 1% of values using TRMM estimates and rain gauge observed values shows a good agreement and have not precluded the use of TRMM data in an EVA for the derivation the short period rainfall return level estimates, although the length of data available, 1998-2015, is shorter than preferred. Also, TRMM data fails to capture the most extreme of observed values which could have implications for the EVA results especially at the longer return periods.

An EVA analysis of daily data was undertaken using TRMM data and observed data. The EVA estimates based upon daily TRMM data were lower than those obtained from rain gauge data. The underestimation was taken into account in the estimation of the 3-hourly values using the correlations found.

Return period values of 3 hours durations with return periods of 50, 100 and 200 years were calculated.

Conclusion

Satellite derived rainfall has been used successfully to calculate rainfall return periods for areas with limited observations. However, the data cannot be used exclusively as verification is always required against local observations to derive bias corrections to ensure robust results.

5.8.2 Observational data availability in Tanzania

Between 2016 and 2018, the Tanzania Meteorological Agency (TMA) and the Met Office have jointly worked on the Climate Adaptation to Risk and for Opportunities in Tanzania (CAROT) [45] project.

This DFID funded project aimed to improve the capacity of the TMA to understand user needs and develop services to meet them. An important component of the project was the indexing and digitisation of a large number of paper observational records, based on user needs and with the aim of making the data accessible for enhanced services.

Weather data is collected by the National Telecommunication Centre at the TMA headquarters from the 26 synoptic observation stations by telephone, radio and email. Data from the Automatic Weather Stations is received electronically every hour. Data is collected from the other stations in a monthly basis, usually by post.

Data from the synoptic stations is manually transmitted to the Global Telecommunications System (GTS) and Aeronautical Fixed Telecommunications System (AFTN).

Paper copies of observations are stored in an archive. Requests for records of historic data are made by a number of users such as researchers, construction companies and agricultural stakeholders and are fulfilled by the climatology team. This paper archive is a valuable resource, but is vulnerable to the environment in which it is stored, so potentially could be lost.

This risk has started to be addressed by the CAROT project.

- TMA have created an inventory of the paper climate records for 900 rainfall stations plus all 26 synoptic stations. This makes the paper records more easily searchable.
- TMA carried out a gap analysis of digital database by comparing with the paper inventory database. This helped to prioritise which paper records to salvage first.
- TMA scanned some of the gaps for the synoptic stations (~50,000 images).
- A third party company scanned over 300,000 pages. This included both synoptic and rainfall stations. Approximately 175,000 images were of rainfall stations, which is the equivalent of approximately 20 years of data for over 700 sites.
- The images have been saved electronically and indexed increasing the efficiency of searches.
- The third party company also ‘keyed’ the values contained in the images of ~400 station years of rainfall data which have been loaded into the TMA digital database (equivalent to 10 years of data for 40 sites).
- TMA also ‘keyed’ the values for about 100 years of rainfall, Tmax, Tmin for the synoptic sites, which will soon be available in the digital database.
- The project has funded the purchase of two scanners to ensure TMA can preserve more paper records.
- Training in the digital database both in loading the data and also accessing the data was also funded.

This has culminated in the TMA digital data archive (Clidata) now containing data from over 2000 stations. This is made up of data from 29 synoptic stations (current and closed), 140 climatological stations with the remainder being rainfall stations. Data from some synoptic stations is available from the 1940’s and 1950’s, although many were installed more recently. For rainfall stations, data are available from some sites from the 1920’s and 1930’s. Other sites have variable record length and

[45] https://www.metoffice.gov.uk/services/international-development/carot

completeness due to the voluntary nature of data supply and the difficulty in maintaining these sites on a national basis.

5.8.3 Climate modelling

Research into regional climate modelling (RCM) in the past five years has developed rich sources of data through projects such as CORDEX (Coordinated Regional Climate Downscaling Experiment) and Future Climate for Africa (FCFA). These have used the approach of downscaling and analysing a number of global climate model (GCM) ensembles from the order of 100km to nearer 10km. These approaches aim to represent the model uncertainties in specific parameters in order to represent the spread of outcomes for the whole of Africa or a specific region within Africa.

Some studies have shown that RCMs fit observations better and reduce spread relative to the driving GCMs. Whilst driving GCMs capture the broad spatial and temporal patterns, RCMs have been shown to represent the magnitude and timing of temperature and precipitation better, for example, the Sahel wet season and the West African monsoon. The improvement seen with the use of RCMs is likely a response to better representation of regional and local processes. RCMs have also been shown to represent events that have the potential to lead to significant impacts, such as temperature extremes and heatwaves.

Future Climate for Africa (FCFA)[46]

The FCFA project aims to generate new knowledge about climate variability and change in Africa through distinct projects that sit within FCFA. The basis of much of the analysis and application of regional climate model information is the IMPALA (Improving Model Processes for African Climate) project, which has developed a very high resolution (4.5km grid spacing) data set for the whole of Africa based on the Met Office Unified Model and known as CP4-Africa. These data sets allow key processes and local-scale weather to be better captured, enabling better representation of African climate variability and changes, and extreme phenomena, 5-40 years into the future.

The IMPALA data set is being used within FCFA with the aim of generating easy-to-use climate information products tailored to decision-making. AMMA-2050 (African Monsoon Multidisciplinary Analysis) is investigating how physical processes interact to cause 'high impact weather events' such as storms and heat waves. HyCRISTAL (Integrating Hydro-climate Science into Policy Decisions for Climate-Resilient Infrastructure and Livelihoods in East Africa) is developing new understanding of climate change and its impacts in East Africa, working with the region's decision-makers to manage water for a more climate-resilient future. FRACTAL (Future Resilience for African Cities and Lands) is embedding researchers into the working world and practices of decision-makers in three specific city-regions: Lusaka, Maputo and Windhoek. In this co-production project, learning lab events are being used to bring together decision-makers, practitioners and researchers from the fields of climate science, social studies, governance and adaption to frame climate-related problems and consider solutions.

One example of further application of the FCFA data and approach is the Climate Information for Resilient Tea Production (CI4Tea) project, which is using local observations and climate projections to investigate changes that are of particular relevance to the tea producing countries of Malawi and Kenya.

[46] http://www.futureclimateafrica.org/

5.8.4 Seasonal forecasting

The use of seasonal forecasts in operations is becoming more commonplace as skill levels for predictions from weeks to months in advance is increasing in some regions. The DFID funded WISER[47] project SCIPEA, for example, has improved access to seasonal forecast data through the development of a regional consensus on the seasonal outlook, which can then be used as input to national seasonal outlooks. SCIPEA has also transformed access to data through a dedicated portal[48] that provides easy access to dynamical forecast data and observations for calibration. Another focus of this project is the concept of "training through doing", a co-production activity in which local NMHS are fully involved in the preparation of seasonal outlooks based on global seasonal forecasts.

Seasonal and sub-seasonal forecasting is also being applied to the requirements of adaptive social protection in the Sahel as part of the ASPIRE[49] project which is also part of the WISER programme. Social protection mechanisms, including aspects of financial protection for livelihoods, can help to mitigate impacts such as those from natural hazards. Using a co-production approach, NMHS and social protection stakeholders are working together to identify requirements for improved information.

DFID & NERC funded Science for Humanitarian Emergencies and Resilience (SHEAR)[50] research programme project ForPAc: Towards Forecast-Based Preparedness Action[51] is a research consortium, which aims to improve the credibility and usability of weather, sub-seasonal and seasonal forecasts as the basis for Forecast-based Action (FBA). Through the development of preparedness frameworks and tools, mitigations such as forecast-based financing are being considered. In support of this, early warning systems are being developed to include decision-relevant climate metrics such as wet season onset that are of relevance to local and regional stakeholders.

[47] http://www.metoffice.gov.uk/about-us/what/international/projects/wiser
[48] http://scipea.iri.columbia.edu/maproom/
[49] https://www.metoffice.gov.uk/about-us/what/international/projects/wiser/aspire
[50] https://nerc.ukri.org/research/funded/programmes/shear/
[51] https://www.forpac.org/

6. IMPLEMENTATION ROAD MAP AND REQUIREMENTS

6.1 Introduction

This chapter seeks to outline the key elements of a road-map for development of insurance tools to assist in building resilience to climate hazards and risks in Sub-Saharan Africa. We provide a table and descriptions of a number of potential ideas and opportunities which the World Bank might consider as intervention targets. These opportunities have been identified both through a review of the needs (now and in the future) and analysis of the current insurance landscape as presented in Chapter 5. After presenting the opportunities, the chapter goes on to outline the key elements of designing and implementing insurance solutions. This section is necessarily generic, but aims to capture the main aspects which would need to be addressed when considering specific project design.

A final section brings this all together in presenting some tangible opportunities for projects, concentrating on the target countries identified in Chapter 3 and, within those, taking a deep dive on three countries to demonstrate the way in which a roadmap for programme design might be constructed.

6.2 Key Interfaces and Co-Benefits

6.2.1 The Formal Insurance and Adaptation Interface

For a multi-faceted risk-scenario in extreme weather events, it is clearly unrealistic to think about a single intervention or strategic policy response that can offer adequate insurance. As this report has been pointing out, different alternative instruments have their own share of promises as well as drawbacks. In order to get the best results they need to be approached comprehensively within a larger disaster management and financial risk management strategy. At the level of households, the gamut of traditional response and adaptive mechanisms such as kinship ties, community reciprocation, savings and other informal pooling arrangements, although effective at times when shocks are less severe or individual impacts vary, are likely to be inadequate or inappropriate for covariate shocks. Other local adaptive mechanisms, including switching over to alternative and more resilient agricultural practices or diversifying livelihoods, are considered to have a higher risk-pooling capacity. The available evidence suggests that such local experiences can have important lessons for a holistic, broad-based weather risk insurance strategy.

Banking and market based insurance instruments present a more formal, institutional approach to coping with adverse weather events; as highlighted by the numerous case studies and initiatives presented in this exercise. However, several barriers deter access to formal insurance products by the poor, most notably the lack of adequate collateral. Insurance providers are also reluctant to venture into what is often viewed as a “low-yield, high-risk” market. Instead, microinsurance, may present a possible solution to these populations at risk. These instruments are of great help in providing post-disaster liquidity, and helping to protect livelihoods. Recent experiences, for example the HARITA initiative in Ethiopia have demonstrated microinsurance can also help in diversifying and promoting investments into alternative practices that can yield higher returns to the farming households. When packaged together with both microcredit - lending funds to help poor communities diversify into higher income generation activities - or microsavings - allowing facilities for small deposit schemes for emergency needs - the utility of microinsurance is much greater given the risky livelihoods and low resource base in poor communities. However, extreme weather events and disasters preset a special challenge to micro-insurers because of the covariate nature of the risks. Since natural disasters affect entire communities or regions at once, the solvency of the insurer can be threatened if not adequately backed by guaranteed re-insurance or prudent diversification.

The possibilities of insurance and adaptation interactions will increase with better understanding of client's capacity. Source: Ripin Kalra

Issues of sustainability and scaling up will be addressed by taking into consideration both the financial viability of these schemes to the insurer, as well as the affordability to households at risk. The large number of individual contracts with low asset value and the difficulty of administering the schemes often lead to higher premiums, which reduces demand from the poor who are often at the highest risks. This is where there is significant potential for adopting different types of insurance instruments and delivery channels. While support from public agencies – either through subsidies to the insurer or allowing some extent of re-insurance – can be a part of the solution to make insurance products (and the premiums) more affordable to the poor, what seems best is an integrated strategy with microinsurance built into the larger family of social safety nets managed by national governments. For example, anti-poverty programmes (such as food-for-work schemes) can be tailored to include microinsurance products. Local stakeholder groups or community associations can be entrusted with the responsibility to manage microinsurance programmes specifically catering for climatic hazards and weather risks as a part of a wider set of operations; such as running low-price food stores, grain banks or other livelihood programmes. Alternatively, they can encourage productive investments or contributions to savings schemes from where the premiums can be subsidized. The success and efficacy of these microfinance services can also be strengthened by linking with other public social welfare programmes, including literacy, health and hygiene and nutrition; all of which directly or indirectly help in building resilience. Another approach can involve public agencies helping several localised microinsurance groups operating over a larger geographical area to pool their resources together, and thereby allowing economies of scale in risk capitalization; such spatial pooling has been suggested as a possible option for climatically diverse countries such as Ethiopia[52].

Box 6.1: Potential for Integration of Insurance with Safety Nets and Adaptation

Mozambique:

- Mapping of local adaptation practices
- Create overlaid databases integrating hydrological/meteorological risks with regional poverty profiles, and livelihood compositions (National Statistics Office?). The idea is to identify regions/communities with multiple vulnerabilities – higher ecological risk exposure, low adaptive power (risky livelihoods) and high sensitivity (higher poverty, lower literacy, low levels of non-agricultural occupations, lower levels of financial inclusion)
- Conduct systematic stakeholder assessments – (power-interest grids) and convergence (inter-sectoral coordination between public and private agencies) simulations

Ethiopia:

- Mapping of local adaptation practices and community associations
- Capacity-building and intensive awareness campaigns – horizontal knowledge sharing examples from Tigray basin examples
- Stakeholder assessments and integrated vulnerability profiling, for priority interventions
- Mapping social safety nets and coverage – using ICT-enabled devices to track beneficiaries

Nigeria:

- Mapping of local adaptation practices and community associations
- Integrate poverty profiles with ecological risk profiles at regional and sub-regional level There are a large number of schemes where the formal-informal interface is already mapped (Appendix 1).

6.2.2 Co-Benefits from Insurance Market Development into Adaptation

Developing the insurance market has a number of co-benefits that can improve the adaptive capacities of the shortlisted countries. Development of insurance markets requires much of the same infrastructure as you would need to develop adaptation capacity, the most prominent being financial strategy development and improved weather data infrastructure on precipitation/temperature/ seasons. In addition, mainstreaming insurance brings co-benefits to adaptation such as raising risk

[52] Meze-Hausken E, Patt A, Fritz S. (2009) Reducing climate risk for micro-insurance providers in Africa: A case study of Ethiopia, *Global Environmental Change* 19 (2009) 66–73.

awareness amongst the population, reducing financial losses from weather events and transferring the financial risk more widely where the sovereign itself is unable to cope with it.

6.3 Identifying Opportunities

A matrix of opportunities for the development of insurance or insurance-like programmes and markets is provided in Table 6.1. The different insurance mechanisms which might be applicable to meeting the identified needs are described in general terms below. Further ground investigation is required to develop these ideas into robust propositions.

Programme	Climate Exposure	Buyers	Instrument	Data requirements	Potential countries/areas
Sovereign disaster risk financing strategy	Increasing variability in climate and thus weather catastrophes requiring sovereign intervention	Sovereign, but could drill down to departments and quasigovernment agencies	Multiple, including risk assessment tools	For risk assessment, wide-ranging but not fixed, but including primary and secondary hazard data, vulnerability data and quantitative impact data	All. Different countries will require bespoke strategies which will best fit their particular requirements.
Index-based drought insurance for agriculture	Changing rainfall patterns - more and longer droughts, higher temps	Farmers, cooperatives, marketing companies, processors, suppliers	Weather index insurance on low rainfall	Daily or dekadal rainfall data, satellite and/or gauge, plus other derived satellite products	All. Many variants possible including linking to credit and hybrid schemes linked to contingent safety net programmes
Tropical Cyclone index insurance	Potential for higher frequency and intensity of TCs, sealevel rise leading to increased storm surge risk	Various including agriculture, sovereigns, infrastructure developers, homeowners, MSMEs etc	Index on cyclone effects (wind, surge & rain)	Tropical cyclone tracks, real-time hazard model (for surge), satellite rain data	Coastal Mozambique, Madagascar
All-perils crop insurance	Changing rainfall patterns, more and longer droughts, more and more intense high-rainfall events, higher temps	Farmers	Traditional allperils crop insurance	Many approaches but indemnitybased products require good understanding of past loss history related to climate and other events (e.g. disease)	All, but likely only to be suitable for high-value agricultural areas and relatively wealthy countries (given almost certain need for premium subsidy)

Locust infestation protection	Changing weather patterns leading to higher incidence of infestation	Farmers, cooperatives, marketing companies, processors, suppliers	Index on forecasted locust infestation	Various data used to formulate probabilistic infestation forecast with 3-6 months lead time	West Africa, Madagascar

Programme	Climate Exposure	Buyers	Instrument	Data requirements	Potential countries/areas
HEP water supply hedging mechanism	Increasing variability in water availability for power generation	Electricity generation companies	Weather derivative on low/high rainfall	Satellite, rain gauge data and stream flow data, current and historical. Modelling of hydrological regime	Several major schemes in Africa: Ethiopia (80% HEP already), Kenya, N Tanzania; Mozambique, South Africa; West Africa (Ivory Coast to Guinea); Zambezi
Traditional weather derivative	Higher use of cooling due to rising temps and economic development/urbanisation. (Likely lower interest in heating requirement).	Energy supply companies	Weather derivative on temperature	Dense, reliable temperature data in real time and historically	Countries/regions with rapid urbanisation and high GDP growth

Property/ catastrophe market development	Mainly urban flooding, but some windstorm	Householders, businesses	Traditional indemnity insurance	Historical loss data, some hazard data, catastrophe risk modelling	Wealthier and rapidly growing countries such as Nigeria, Kenya, Ghana, Ethiopia
Index-based flood product	Urban flooding	Low-income population, MSMEs	Index on rainfall or river flow	Detailed rain data for entire river basins, stream flow data, hydrological modelling	e.g. Nairobi, Kampala, Lagos, Accra, Free Town, Maputo

Table 6.1: Insurance and insurance-like instruments and programmes with possible application in Sub-Saharan Africa

6.3.1 Sovereign disaster risk financing strategy

This would include risk assessment as well as development of instruments/programmes and policies to support sovereign risk management. It would need to take into account participation in regional schemes (e.g. African Risk Capacity), and may also address regulatory and broader private market development issues. Such opportunities are already a focus of World Bank activities in Sub-Saharan Africa (e.g. World Bank 2012, GFDRR risk reviews in preparation), and further details are not thought to be necessary here.

In terms of data requirements, the risk assessment phase of any such strategy would need to address data availability at hazard, vulnerability and loss levels. It may also support development of both data collection infrastructure and catastrophe risk models that can both be used for supporting other insurance mechanisms at a national and sub-national level. Again, World Bank experience is substantial and growing fast in this area, both within and outside of SSA.

6.3.2 Index-based drought insurance for agriculture

It is important to recognise that activities in this area must focus on building on existing pilots and successes and also learning from failures. In particular, consideration of activities will need to address:

- The use of risk aggregators (i.e. groups of individuals at risk) for distribution and alignment of interest between insurer and insured and for management of basis risk at the individual level;
- Building on existing informal risk sharing mechanisms where possible;
- Possible integration with existing safety net programmes (through contingent scaling up mechanisms); and
- Linkage to disaster risk reduction as part of a comprehensive disaster management strategy.

Data requirements for index-based drought insurance are multi-faceted, and existing projects use a variety of data sources – some newly installed rain gauges, some existing ground-based measurement networks, and some satellite based.

The ability to manage user expectations of an index drought product is a key factor in dictating what data sources might be suitable; the greater the expectation that an index product will respond in lock-step with loss at the individual farmer level, the higher the resolution of data required to underpin the mechanism. Management of basis risk through risk aggregation (by, for example, using insurance to back-stop an existing informal or semi-formal farmers association) or other means of managing expectations can enable lower resolution hazard data to be used, generally making schemes cheaper, quicker to market and more sustainable. Weather index insurance pilots in Africa and beyond are increasingly focused on meso rather than micro-level products in response to the challenges of delivering catastrophe insurance products all the way to vulnerable individuals at a cost that they can afford.

6.3.3 Tropical Cyclone Index Insurance

Index-based insurance for tropical cyclones uses relatively well-developed technology, and can be manifested either as an index on wind speed (or a derivation from wind speed) or as a full modelled loss approach (given the robust basis and broad experience of tropical cyclone catastrophe modelling). Historical cyclone tracks are available for completing historical burn analysis (i.e. as-if losses against an index for a known historical period), as a basis for stochastic event set development in a catastrophe modelling environment, and real-time reporting necessary for triggering coverage. Products could cover sovereigns or meso-level entities including lending agencies, and could include private as well as public sectors. Rain aspects of tropical cyclones will not be straightforward to integrate into a product so may need to be treated differently. We also note that there is a limited marketplace due to limited exposure to cyclone risk in Sub-Saharan Africa, which needs to be taken into account when considering the types of cyclone products that might be developed.

6.3.4 Multi-Peril Crop Insurance

There are many models around and many approaches have been tried for MPCI globally. A good starting point for assessing the potential relevance of MPCI as opposed to index weather insurance is an assessment of the relative risk of direct climate factors against other factors such as pests etc. If climate plays a small role in the overall risk to farmers then weather index insurance is less applicable and MPCI may be more desirable. However, since MPCI is indemnity based the costs are high (as adjustment of agricultural losses is very costly) and it must be integrated into a strong disaster risk management strategy to manage risk and therefore premium levels.

Multi-peril crop insurance data requirements concentrate on the availability of data to seed models of past losses as a guide to pricing coverage. MPCI is indemnity-based, so the data requirement for claims is derived from in-field loss adjustment. Understanding past losses is challenging, however, due to the lack of actual data, so a modelled approach is required; combining hazard and vulnerability data.

6.3.5 Locust Infestation Protection

This concept is not really insurance per se, but is instead focussed on using insurance tools to trigger access to pooled resources to enable early response and reduce the overall impact of pest infestations. Using quantitative tools to control access to pooled resources, particularly across national borders, could provide a key ingredient to more successful and earlier mobilisation of resources to prevent infestations from becoming catastrophic events. Monitoring of meteorological and other precursor conditions is relatively sophisticated across Sub-Saharan Africa, such that outbreaks of, for example, locust swarming/infestation can be forecasted several months in advance. Immediate mobilisation of resources to address the cause of infestation can greatly diminish the likelihood of a particular occurrence becoming catastrophic.

Utilisation of parametric triggers based on forecast infestation probability to unlock an “infestation prevention pool” could ensure that the interests of participating countries and donors are better aligned and the resources are released solely for the designated purpose.

6.3.6 HEP Water Supply Hedging Mechanism

This concept is essentially a hedge for Hydro Electric Power generators against low water flows which could prevent power generation at anticipated levels. The best analogy is fuel price hedging for conventional (hydrocarbon) power generators, although there are some differences in that conventional supply hedging protects against rising cost of fuel, whereas for HEP generators the hedge would be protection against lack of supply of ‘fuel’ (water).

The volatility of water supply to a given HEP scheme can be taken into account in the design phase; a bigger reservoir will enable deeper troughs in water supply to be managed, but has cost implications.

In an age when future rainfall patterns can no longer be reasonably predicted based on past rainfall patterns, the additional investments required to allow for the downside uncertainty in climate-model projections of rainfall may prove prohibitive. It may prove more efficient to manage that uncertainty through insurance/hedging tools once operational rather than in the physical scheme design.

This mechanism would probably require an African weather derivatives marketplace to develop, although contracts may be large enough to place into existing North American or European markets (the lack of correlation with peak risks, such as high or low US temperatures, will be advantageous in enabling this). Data requirements for water supply hedging are predominantly satellite-based rain data, river flow data and, most importantly, sophisticated hydrological modelling. While relatively low resolution rain and stream flow data may be sufficient as inputs to modelling for large basins, the weather derivatives market requires very high levels of data supply rigour such that triggering of contracts is enabled in a fully trustworthy, transparent and reliable way.

Box 6.2: Potential demand for Insurance in Hydro-power

Developing insurance type solutions for the Hydro-power sector has precedents in the World Bank (for instance in South America which is described elsewhere in this report). The project team discussed the possible relevance of insurance to hydro-power sector stakeholders in SSA shortlisted countries.

Variable hydrology can resulted in substantial financial losses in the hydro-power sector either through penalties that are payable if power generation targets are not met or the substantial high cost of emergency power generation when hydro-power fails to generate enough power to meet demand in a drought year. Further discussions with energy providers such as Kenya Electricity Generating Company (KENGEN) and Ethiopian electric Power Corporation (EEPCO) or the country governments reliant on hydro-power could provide confirmation of such financial losses incurred in recent times.

In Kenya, for instance, hydropower is a major installed power source and any failure can result in large financial losses both to the users as well as suppliers of power. In Sudan demand for energy far exceeds supply and any loss of hydro-power supply from neighbouring Ethiopia can result in expenditure towards emergency power generation. Power inter-connectors or pools are also price sensitive as the whole purpose is the availability of affordable electricity. In both cases hedging/ insurance can be considered an option but does not appear to have been explored as yet. For a country (such as Ethiopia) with surplus hydro-power the interest in insurance is likely to be lower. The power sector in the region is quite sophisticated and is appreciative of such risks and thus may be willing to engage in dialogue on insurance related mechanisms.

Reliable data on hydrology can be hard to come by in the public domain although companies such as KENGEN and EEPCO are very likely monitoring the hydrology regularly and should be a reliable source of such information including any recent instances where variation has affected hydropower output.

6.3.7 Traditional Weather Derivatives

Derivatives on temperature are very well established in many commodities markets around the world and there is a robust global appetite. Most weather derivatives are used by power companies to manage demand surges due to hot/cold weather, and such a marketplace may evolve in SubSaharan Africa as urbanisation and economic growth proceed, with global temperature increases also playing a role in making hot weather more common.

With reference to the previous sub-section, we note that there is a correlation between low supply and high demand for hydro-electric power – high power demand will increasingly occur when it is hot, and heat is positively correlated with dryness (and thus potential for erosion of supply) in many parts of Sub-Saharan Africa.

Data requirements for temperature derivatives are relatively straightforward; a reasonably long time series of daily maxima and minima and a reliable real-time source of temperature data at the same site as the historical time series. Temperature is the most robust data measurement in Sub-Saharan Africa, and any investment in necessary real-time instrumentation to underpin a weather derivatives market (for temperature hedges at least) would be very modest.

6.3.8 Property/Catastrophe Market Development

This possible area of activities covers a variety of mechanisms to foster product development in and growth of conventional property/catastrophe insurance markets across the region. There is potential for promoting market growth across a variety of sectors including personal lines, MSMEs and conventional businesses. In addition to protecting physical assets, property/cat insurance can be used to manage business interruption also, which is increasingly necessary for companies operating in the global marketplace. Some areas of intervention may include:

- Increasing efficiency in the marketplace, perhaps by developing common goods, such as risk analyses and models, harnessing technological advances (mobile banking being a good example) and building capacity;
- Supporting regulatory strengthening to build consumer and investor confidence; and Integrating micro insurance into the conventional insurance marketplace.

In particular the traditional insurance marketplace in Sub-Saharan Africa will need to address flood risk in urban areas and for major infrastructure. As previously outlined, flood risk management is a particularly challenging area even in the developed world, and even basic insurability against flood may not be possible without parallel initiatives in planning controls for flood-prone areas.
Data requirements for development of the property/cat market are mainly going to be related to inputs for flood modelling.

6.3.9 Index-Based Flood Product

Index-based flood insurance is probably only appropriate for low-income populations living in semiformal settlements exposed to flooding. Such populations are unlikely to have access to traditional property/cat insurance tools, and are also unlikely to come under the influence of formal planning or other risk management controls. Most of Sub-Saharan Africa's flood risk is to low-income populations in major cities such as Lagos and Maputo, and linking disaster risk reduction with indexbased insurance, through community-based groups, may be the most effective way of mitigating the risk and alleviating the burden on the state.

Index-based flood insurance has been tested in Jakarta, Indonesia, where the test was not successful, due to a variety of reasons including the lack of uptake, but other approaches might be worthy of investigation, including modelled-loss parametric products. There is also a need to link insurance and DRR with early warning; better understanding of hazards integrated with early warning can improve both short- and long-term outcomes.

Index-based flood insurance requires excellent rain and stream-flow data and some amount of flood modelling (depending considerably on the type of product developed). Satellite-based techniques of flood inundation mapping have improved significantly over the past few years and further progress may enable satellite-based triggering of parametric flood insurance in some areas. The lack of effective and efficient flood risk programmes based on indemnity insurance principles in the developed world are a key driver of the search for index-based alternatives which can move the burden of floods from the state to the private markets.

6.4 Developing and Implementing Insurance Programmes

For any insurance programme, its development has to go through a series of steps maintaining focus on the specific needs of the target clients. The various steps to be taken include:

- Defining the target client and the geographical region in which to operate, understanding the needs and challenges of the target client, understanding the ability and willingness to purchase the product, and understanding the economic activities of the target clients.
- Develop a prototype which will be modified together with the target clients – involve them in the product development process.
- Determine the price of the product while adjusting the parameters to ensure that it is affordable to most of the intended beneficiaries, and also ensure that the product captures the magnitudes of events to minimise basis risk.
- Decide on the distribution channels and the management of operations: ○ Collection of premiums in a cost effective manner;
    - How information about the client will be collected, stored and retrieved quickly as needed;
    - Claims payment in a timely manner to serve the purpose for which insurance was purchased.
- Ensure that the target beneficiaries understand the product they are buying, and the product benefits through client education and training.

The following sections have been written in generalised terms, as a starting point for considering how a private, public or PPP project aimed at implementing a new insurance mechanism might be conceptualised. Clearly there will be many external factors which will have a bearing on the details of a project development and implementation plan.

For instance Table 6.2 provides a rapid assessment of how the shortlisted countries may be viewed from the perspective of a re/insurance provider looking for indications of how the markets may favour the development of insurance products. The list has been interpreted from industry literature on the status of the SSA insurance market.

SUMMARY INSURANCE LANDSCAPE ASSESMENT IN AFRICA [Shortlisted countries]		
Generic Enabling Factors[53]	**Comment on Status**	**Significance for insurance market development**
Economic growth & stability	Favourable	Growth anticipated in insurance market
Wealth gap	High	Products needed specific for low-income groups
Culture & religion	Significant	Culture and religious factors key in product design
Education	Low	Literacy barriers to micro-insurance contracts
Risk awareness	Low	Barrier to formalising risk transfer at all levels
Delivery channels	Several	Strong community and sub-regional associations
Political stability	Variable	Barrier to markets
Property rights	Difficult	Barrier to markets, particularly traditional indemnity-based property insurance
Legal insurance framework	Poor-medium	Requires legal framework development

Table 6.2: Summary insurance landscape assessment in shortlisted countries

6.4.1 Business Plan

Developing and implementing an insurance program for climate adaptation begins with the creation of a business plan which gives an overview of the product, including details of how and when the project's objectives are to be achieved. The project also needs to assess the capital requirements and allocate resources that will enable achievement of the set milestones within the given timeframe. Capital investment can be any investment in equipment (e.g. weather monitoring for triggering of index-based products or innovative loss data collection for indemnity coverage) or software (e.g. data processing for claims payments). Identification of underwriting capital is also critical.

The next step is to define the target group and to establish a relationship with the relevant stakeholders which generally include, but are not limited to:

[53] Interpreted from Swiss Re (2011) 'OAI presentation'.

- Regulatory bodies;
- Other interested government agencies (particularly for sovereign products);
- Meteorological offices (particularly for index-based products);
- Disaster management agencies (particularly for schemes linked to disaster risk reduction);
- Local insurance market;
- Distribution channels (if not utilising traditional direct/broker/agent model);
- Reinsurance companies (if risk cannot be retained in local markets); Banks and lending institutions (if insurance is linked to credit); Clients (farmer organisations, community groups, etc.).

When introducing a new type of insurance into a country, the governing regulatory body must be notified and consulted to ensure that activities meet all legal requirements. Regulators will usually provide guidance on legal steps to be taken in order to operate in the local market, specifying any peculiarities that may exist. Many of the insurance products and programmes considered in the previous section are sufficiently innovative that existing insurance laws and regulations may not explicitly cover these types of transactions (particularly index-based insurance products, weather derivatives and microinsurance), so additional resources will be required to work with regulators to enable effective implementation of the product.

Engaging with the various local partners provides an opportunity to refine the goals of the project based on knowledge of the particular environment. This liaison will build a firm foundation with access to expertise, databases of information and insight into the local market. At this stage, the vulnerabilities of the target group and demand within the market should be analysed through a combination of consultations, surveys, workshops or bilateral meetings with participants from each of the stakeholder groups. These meetings provide opportunities for individuals to verify their risk exposure and express their willingness to purchase products to mitigate that risk. We note that the material presented in this report is high-level and any actual development of an insurance programme will require significant market analysis prior to finalisation of programme aims and planning for implementation.

6.4.2 Client Value

Earlier chapters have discussed how client value is key to sustainable insurance markets. Failing pilots are often characterised by the lack of take-up amongst clientele because they do not see the value of investing precious resources into premiums. Although there could be a variety of reasons for this, it is often the case of insurance being designed to be fit-for-purpose. Failed pilots can put the instrument such as insurance into disrepute whereas the problem lies with the design approach. Going forward understanding the specific requirements of the client as the basis of the “insurance design brief” is likely to improve the chances of the insurance product being successful.

6.4.3 Data Requirements and Modelling

Following the identification of the risk exposure of target groups, the data that will be required to develop and manage a suitable product must be determined. At this point the available hydrometeorological data and infrastructure must be considered. The necessary data must be identified, sourced, mined and manipulated in order to develop a hazard and risk ‘model’ that adequately represents the impacts and losses associated with an event of the particular peril(s) under consideration. Historical data input contributes to the hazard modelling so the viability of a product is dependent on the quality and quantity of existing data.

It may be necessary to use satellite sources primarily for model inputs since on-the-ground data is not always available in usable formats and is likely to have gaps or may be taken from insufficient measuring points and thus are not truly representative of the area to be covered. For these reasons, the on-the-ground data may be retained for comparisons and verification of the model outputs.

For index-based products, the intensity of an event and the expected loss will exactly determine the level of coverage or payout that is needed following an event; the higher the intensity of the weather event, the higher the expected loss. The difference between the expected loss and actual loss estimates reported should be minimal so that the hazard model is able to capture historical patterns and project realistic outputs. Thus the credibility of both historical and, particularly, realtime weather data in index-based programmes is critical to the viability of the product.

For indemnity-based products, hazard data requirements are less critical, but knowledge of past losses is important, or if those are not available then a risk model would likely be required including both hazard and vulnerability information to replicate likely loss history.

6.4.4 Pricing

Once a loss profile for the product has been developed and calibrated, a pricing structure is formulated. This should detail how much premium will be paid for the corresponding coverage. It is important to analyse different price structures based on a few main factors.

I The capacity of the intended beneficiaries to purchase the product, considering what features could be varied or added to the product design:

a. *Parametric vs. Indemnity* – Indemnity insurance has many associated costs that are not incurred in the parametric versions of policies. With parametric insurance administrative costs are significantly lower since it is not necessary for loss adjusters to be deployed after an event and claims processing is faster and cheaper.

b. *Flexibility and Control* – Standard indemnity products generally limit the control a client has over the premium paid (due to the requirement that the full value of the assets being indemnified must be covered by the insurance policy), although there are many exceptions available in developed insurance marketplaces. To provide more flexibility, parametric coverage may be offered with variable attachment (deductible) and exhaustion (limit) values acting as book-ends to the coverage or using blocks of limits with each block having a set value and each client having the ability to purchase multiple blocks. Using this method, the insurer can determine the price of a single block at a level that is affordable to persons in the lowest economic bracket within the target market. Thus, the entire group is accommodated, with persons in higher economic brackets able to 'stack' their coverage.

II Speed of payment – The design of the product has to consider how fast payment is needed after an event. Indemnity cover requires beneficiaries to submit a claim to the insurer before a loss adjuster investigates this claim and eventually for payment to be made. This generally takes weeks to many months or even several years in some cases. The process for parametric insurance is a lot shorter and more transparent since payouts are based on the value of the hazard parameters which are decided at the inception of the policy.

III Adequacy of funds received – For non-sovereign coverage, the value of the payment received needs to be sufficient for the insured to restore normalcy in their lives or businesses until income can be earned again. The trends seen through an assessment of historical events indicate that varying levels of damage can occur depending on the intensity of the peril. With an indemnity product, the loss adjuster is able to approximate the damage after visiting the insured property. The parametric option requires modelling to match the strength of the hazard to the likely damage that would be caused and thus the level of payout received. Adequacy of funds in the sovereign risk financing area is less critical as sovereigns generally have sufficient capacity to manage at least some of the risk themselves (indeed, most manage all of their risk themselves at present.) However, specific sovereign insurance for infrastructure projects or to provide short-term liquidity after major disasters do need to be closely related to required funding levels.

IV The clients' needs and the requirement to create confidence among the client base about the insurance products developed, insurance in general and the ability of a given product to pay in case of an event, especially in the areas of:

a. *Claims Settlement*: Parametric vs. Indemnity – Trust with indemnity cover is quite low since the insurer (through the filter of a loss adjuster) has some control over whether a claim is paid and the amount of the benefit. Parametric policies specify the requirements for a payout at inception with a third party (calculation agent) monitoring the parameters of covered perils and indicating to both the client and the insurer when a payout is due. Confidence is built with this design since this method is deemed unbiased and all parties are able to easily monitor the hazards and can verify whether a payout is required. Equally, projects that are not delivering client value are likely to be a cause of reputation risk for the insurer and undermine trust in the product.
b. *The ease in understanding the message*: - While considering minimising the costs is a priority in the development of the pricing structure, the simplicity of it must be taken into account. If the product is affordable but too complex to be understood easily by most potential clients, the uptake will be severely hindered. Even though the design may cater to their needs, persons need to be fully aware of what they are purchasing to maintain trust in the products.

6.4.5 Distribution Model

Traditionally, insurance is distributed either directly (usually confined either to sovereigns, medium and large businesses or 'commoditised' personal lines such as motor insurance) or via a broker/agent. In development contexts, the traditional distribution model may not be appropriate, particularly for new product types. In this case, alternative distribution models need to be considered, particularly leveraging existing channels with which the target clients already have a relationship (preferably but not necessarily through provision of a financial service). When creating a non-traditional distribution model, the target market is initially analysed to determine the appropriate framework. The design will vary depending on access to the target market, level of insurance knowledge of the target group, and the capabilities of the distributors. The distribution model should be structured in the most cost effective way to meet the targeted clients.

A significant portion of the overall cost of insurance products lies in the distribution expense. The policies may be sold directly to individuals, however, this is expensive. The distribution channels expect compensation, and potentially the chance to earn money from selling the policies. Furthermore, the administration of a high number of small policies is expensive and this may make the policies unaffordable for the targeted clients. Another option is for the insurer to sell a group policy to a financial institution which aggregates premium from beneficiaries. The sale and administration of a group policy is much cheaper than individual policies as there is only one policy with high premium instead of a high number of policies with small premium per policy. However, the insured (financial institution) has to carry costs from the enrolment of its members, and such cost has to be reimbursed. The group policy can be varied to provide a third option where premium is paid by the insured institution on behalf of its members. There is no premium collection process associated with this policy and therefore a cost reimbursement is not necessary.

Intermediaries used for the benefit of lowered costs can be: cooperatives, credit unions, or any associations or bodies that act in the interests of its members. Groups such as cooperatives and credit unions have similar interests and needs so they can be used to aggregate potential clients. It is more challenging to reach some sectors (e.g. agriculture) with individual marketing and selling. Another benefit of group distribution is that it provides a forum where peer support can be provided at the comfort and discretion of the client from a source that is already trusted.

6.4.6 Operations

Day-to-day activities for the operations of the product range from administering new policies to claims payments. These processes must be thoroughly planned with consideration for the culture of the market to ensure smooth transactions.

I Marketing of products

II Enrolment of new policyholders

- Enrolment forms
- Collection of premiums
- Issuing of policy documents
- Storage of data
- Inception date and policy duration

III Claims processing and payment

- Monitoring of triggers for index-based policies
- Loss adjustment for indemnity policies
- Calculation and execution of settlements

IV Reinstatement/renewals

Impact monitoring of insurance instruments should also be considered within the initial phases of the operational management framework of the product design. The outcomes from the products being implemented should be compared to the objectives listed within the initial phase and any benchmarks set. Indicators should be utilised so that any discrepancies can be easily identified and addressed. Supervision of the overall product operations is essential in gaining experience and learning from any shortcomings that emerge.

6.4.7 Training

Insurance products developed for climate adaptation are often innovative and sometimes unique. In the case of Sub-Saharan Africa (excepting South Africa), insurance penetration is so low that even traditional insurance products are not understood and in the experience of a small proportion of the population. Therefore, an element of training and education should be built into the product distribution structure to ensure that people understand what they are buying. This education should be given to all stakeholders in the product distribution chain, especially the final beneficiaries.

The education component is administered to the three main stakeholder groups focuses on how the product works as described below:

I Insurer

- Contract design processes and pricing
- Designing insurance policy documents, reinsurance term sheets and reinsurance contract
- Contract monitoring
- Claim processing

II Distribution Channel

- Contract design process
- Designing client information sheets
- [Client] orientation and training
- Premium reporting
- Contract monitoring
- Claim processing and managing insurance settlements

III Client Groups

- Contract features
- Premium and Sum Insured
- Identity of weather station or grid allocation
- Weather parameters
- Trigger levels and payout rates
- Loss adjustment process (for indemnity programmes)
- Claims processing

6.5 Implementation Roadmaps

This section provides a brief overview of the general requirements for insurance product development and goes on to introduce some ideas concerning country-specific roadmaps within the Sub-Saharan Africa context.

6.5.1 General Roadmap for Insurance Product Development

Insurance products are all underpinned by a risk analysis which includes, in some form or another, the following three elements:

- Hazard
- Vulnerability

- Value

A ‘loss’ analysis based on history (or a modelled representation of history) is the basis for pricing an insurance product. For index-based products, the loss analysis methodology must also be implementable in near real time to calculate payouts.

6.5.2 Hazard Analysis

Hazard analysis includes collection of relevant data for the parameter(s) of the hazard(s) which cause damage/loss over as long a historical period as is available. Where history is insufficient to establish reasonable statistical confidence, modelling techniques are used to create a stochastic data set which replicates history but over a much longer time-period.

For index-based products, the hazard parameters must be replicable in real time or there must be a good understanding of differences between real-time and historical parameters for each relevant dataset. It is important to note that a probabilistic hazard assessment cannot be used as a basis for a probabilistic risk assessment.

6.5.3 Vulnerability Assessment

For index-based products, there is a single vulnerability database that is used in both historical and real-time risk evaluation. The vulnerability database attempts to link as closely as possible the level of the hazard to the amount of the loss. The vulnerability may be represented by a continuous function (hazard parameter vs. loss rate), a series of step-like triggers or a single binary trigger. When an event occurs, the same vulnerability relationship (between hazard and loss rate) is applied to calculate the loss under the index contract as was used to calculate the historical losses and thus calculate a price.

For indemnity products, the vulnerability assessment seeks to replicate what will happen on the ground to a given asset or portfolio of assets exposed to a given level of hazard. However, the actual vulnerability of an asset is measured through the loss-adjustment process, so the vulnerability assessment itself is only relevant to the underwriting/pricing of the risk

6.5.4 Portfolio Value

The value or exposure element of the risk assessment turns the loss rate into a payout amount based on a fixed value at risk (exposure). The value at risk is usually built up from a single policy value into a portfolio of risks of potentially different values, potentially different vulnerabilities and potentially different locations (and thus historical and real-time hazard characteristics). For both indemnity and index-based programmes, a price is generally charged for a fixed portfolio of risk; changes to that portfolio would normally generate a change in price, either at a pre-agreed unit cost or after re-modelling of the portfolio.

6.5.5 Pricing and Payout Calculation

Insurance pricing for weather risk has three elements:

- The ‘pure risk’, which is the loss that the portfolio is expected to endure each year based on the average over a large number of years;

- The 'cat load', which is generally calculated as a function of the standard deviation of the pure risk, and reflects the cost of keeping available each year an amount of capital which is much higher than the pure risk amount; and
- The 'expense load', which will include fixed costs (e.g. taxes) as well as recovery of operational costs.

Payouts for weather index insurance products are calculated by a 'Calculation Agent', generally independent of any of the parties to the insurance agreement. The Calculation Agent collects the hazard parameters from a pre-defined data source and completes the calculations to establish the payout amount (all defined in the policy). The payout amount is the amount of the settlement, and is not affected by the level of actual losses endured on the ground.

6.5.6 Country-Specific Roadmaps

Table 6.3 provides a summary by country of potential insurance-related initiatives which might be investigated as part of a programme of investment in support of climate change adaptation. The table currently contains three countries which between them could utilise most of the identified instruments and which address each of the target sectors previously identified. We have summarised data and other requirements for development and implementation of programmes, as well as a brief summary of resource needs.

Country	Relevant Instrument	Sector	Data requirements	Meeting data requirements	Other operational requirements	Activities/Resources (timescale/$investment)
Mozambique	Tropical cyclone index insurance	Sovereign, MSMEs, Infrastructure / adaptation investment protection	Cyclone tracks, modelling	Good cyclone track data is available from IBTrACS and the Joint Typhoon Warning Centre. Detailed cyclone records likely to be available from NMS - Instituto Nacional de Meteorologia	Historical loss/damage data for model calibration	Assess suitability of data from IBTrACS over Mozambique to support this type of scheme. If unsuitable, obtain and quality control data from Instituto Nacional de Meteorologia. Build hurricane model, implement scheme
	Property/cat indemnity insurance	Sovereign, MSMEs, Urban flood risk, Infrastructure / adaptation investment protection	Historical damage / loss data, hazard frequency / severity data for modelling	Some of data on loss, frequency of hazards and their impacts available on disaster databases. Post-event analysis and climatological records held at national level (by meteorology service) likely to give more detailed data for modelling purposes.	Property insurance market development	Assess the availability and suitability of data from disaster databases and BAFG for Mozambique to support this type of scheme. Obtain and quality control available historic data records and any post-event analysis data held at NMS (Instituto Nacional de Meteorologia) Product and market development support, loss adjustment capacity building.

	Index-based flood insurance	Urban flood risk, MSMEs	Historical stream flow and rainfall data for modelling, realtime stream-flow data. Possibly satellite flood data in future	Limited stream data available from Global River Data Centre (BAFG). Rainfall data from 15 stations in Mozambique reporting to the GTS. Satellite and model Re-analysis datasets will be available. Detailed records on stream flow and rainfall likely to be available from the national meteorology and hydrology services. Satellite derived flood inundation products available	Real-time measuring network for stream flow, distribution networks	Assess suitability of available satellite and model reanalysis data sets for this type of insurance. Perform detailed quality assessment of records held on GTS for Mozambique. Obtain and quality control available historic rainfall data records and held at NMS (Instituto Nacional de Meteorologia) and NHS (Direccion Nacional de Agua) Assess infrastructure and operations used at Direccion Nacional de Agua with reference to provision of real-time data. Work with Direccion Nacional de Agua to develop services to support this type of scheme. Integrate the best available satellite products within a hydrological and flood

Country	**Relevant Instrument**	**Sector**	**Data requirements**	**Meeting data requirements**	**Other operational requirements**	**Activities/Resources (timescale/$investment)**
						inundation models. Stream-flow monitoring network, stream-flow modeling, impact modeling.

Ethiopia	Sovereign DRF strategy	Sovereign, may support others	Multiple, should include generation of risk assessment public goods		N/A	Mainly capacity-building, but positively linked to investment in weather monitoring infrastructure and insurance, market development.
	Index-based agri insurance	Agriculture	Ground and / or satellite rainfall data, crop impact data for calibration	Good records of rainfall data (derived from satellite data and verified against gauges) should be available from the National Meteorological Agency, Ethiopia (HARITA project). Crop impact model for *drought* available from Africa Risk View.	Real-time rainfall measurement, distribution networks, product development	Obtain data records from NMA and assess whether existing services provided for insurance sectors would need needs of this type of scheme. Assess availability of real-time crop data from agricultural institutions in for calibration purposes. Substantial resources already committed to pilots and scale-up, additional resources inputs difficult to estimate.
	MPCI	Agriculture	Past loss data, detailed vulnerability data and hazard frequency / severity data for modelling	Some of data on frequency of hazards and their impacts available on disaster databases (e.g. EM DAT, GAR etc) Post-event analysis and climatological records held at national level (by meteorology service) likely to give more detailed data for modelling purposes.	Agricultural insurance market development, adjusting capacity, Government subsidies	Assess the availability and suitability of data from disaster databases available for Ethiopia to support this type of scheme. Obtain and quality control available historic rainfall data records and held at NMS (National Meteorological Agency. Major resource requirements to establish products and markets, build lossadjustment capacity,

						and model past impacts for risk assessment and pricing.
	HEP water supply hedging	Hydro power	Historical rain and stream flow data, detailed modelling, real-time stream flow data	**Rain:** Records from 17 stations available on GTS for historic rain data. Historic rain data could also be obtained from satellite products and Model Re-	Market-making	Assess data available on GTS and suitability of satellite products and model reanalysis data sets for meeting needs on this type of instrument. Obtain rainfall records from National Meteorological Agency. Obtain and quality control rainfall

Country	**Relevant Instrument**	**Sector**	**Data requirements**	**Meeting data requirements**	**Other operational requirements**	**Activities/Resources (timescale/$investment)**

				analysis datasets. Detailed historic rain data will be available from the National Meteorological Agency. **Historic stream flow data** Limited stream data available from Global River Data Centre (BAFG). Hydrological Department (of Ministry of Water Resources) likely to have best records of stream flow data. Hydropower scheme operators also likely to be good sources of stream data. **Real time stream flow data** Best source likely to be Hydrological Department (of Ministry of Water Resources).		records from Hydrological Department. Assess infrastructure and operations and Hydrological Department with reference to provision of real-time data. Work with Hydrological Department to develop services to support this type of scheme. Modelling of basin and scheme water supply and holding capacity, monitoring rain and stream-flow, investment in creating weather derivatives market.
	Property/cat indemnity insurance	Sovereign, MSMEs, Urban flood risk, Infrastructure / adaptation investment protection	Historical damage / loss data, hazard frequency / severity data for modelling	Some of data on frequency of hazards and their impacts available on disaster databases (e.g. EM DAT, GAR etc) Post-event analysis and climatological records held at national level (by	Property insurance market development	Assess the availability and suitability of data from disaster databases available for Ethiopia to support this type of scheme. Obtain rainfall data records and post event analysis held at National Meteorological Agency (NMA) Product and

Country	Relevant Instrument	Sector	Data requirements	Meeting data requirements	Other operational requirements	Activities/Resources (timescale/$investment)
				meteorology service) likely to give more detailed data for modelling purposes.		market development support, loss adjustment capacity building
Nigeria	Index-based ag insurance	Agriculture	Ground and / or satellite rainfall data, crop impact data for calibration	Limited GTS data from Nigeria (4 stations: Lagos, Kano, Sokoto and Enugu) Detailed rainfall data will be available from Nigeria Meteorological Agency (NIMET). Detailed crop data from	Real-time rainfall measurement, distribution networks, product development	Assess quality of data available on GTS for Nigeria. Obtain and quality control rainfall records from NIMET. Assess infrastructure and operations used at NIMET with reference to provision of real-time rainfall data. Work with NIMET to develop services to
				agricultural institutions and possible NIMET (if they provide agro-met services)		support this type of scheme. Substantial resources already committed to pilots and scale-up, additional resource inputs difficult to estimate.

	MPCI	Agriculture	Past loss data, detailed vulnerability data and hazard frequency / severity data for modelling	Some of data on frequency of hazards and their impacts available on disaster databases (e.g. EM DAT, GAR etc) Post-event analysis and climatological records held at national level (by meteorology service) likely to give more detailed data for modelling purposes.	Agricultural insurance market development, adjusting capacity, Government subsidies	Assess the availability and suitability of data from disaster databases available for Nigeria to support this type of scheme. Obtain and quality control historic data records and post event analysis from NIMET. Major resource requirements to establish products and markets, build lossadjustments capacity, and model past impacts for risk assessment and pricing.
	Energy demand weather derives	MSMEs	Long term and realtime temperature data	Historic records of temperature data (from 1973) from GTS available in HadISD dataset. However, only uses the data from the 4 stations in Nigeria reporting. Long term and real time temperature data available from satellite products and model reanalysis. Detailed temperature records will be available from NIMET.	Derivatives / commodity market development	Obtain HadISD dataset Assess which satellite products and model reanalysis data sets would be most suitable for this type of instrument. Obtain and quality control historic records from NIMET. Assess infrastructure and operations used at NIMET with reference to provision of real-time rainfall data. Work with NIMET to develop services to support this type of scheme. Product development, demand analysis

Country	**Relevant Instrument**	**Sector**	**Data requirements**	**Meeting data requirements**	**Other operational requirements**	**Activities/Resources (timescale/$investment)**
	Index-based flood insurance	Urban flood risk, MSMEs	Historical stream flow and rainfall data for modelling, realtime stream-flow data. Possibly satellite flood data in future	Records from 4 stations available on GTS for historic rain data in Nigeria (Lagos, Kano, Sokoto and Enugu) Historic rain data could also be obtained from satellite products and Model Reanalysis datasets. Detailed historic rain data will be available from the NIMET. Limited stream data available	Real-time measuring network for stream flow, distribution networks	Assess quality of data available on GTS for Nigeria Obtain and quality control rainfall records from NIMET. Assess which satellite products and model reanalysis data sets would be most suitable for this type of instrument. Obtain and quality control rainfall records from Department of Hydrology and Hydrogeology Assess infrastructure and operations and
				from Global River Data Centre (BAFG). Department of Hydrology and Hydrogeology (Federal Ministry of Water Resources) likely to have best historic and real-time records of stream flow data.		Department of Hydrology and Hydrogeology with reference to provision of real-time data. Work with Hydrological Department to develop services to support this type of scheme. Stream-flow monitoring network, stream-flow modelling, impact modelling

Table 6.3: Relevant insurance instrument in three specific countries (Nigeria, Ethiopia and Mozambique)

6.6 A Policy Framework for Implementation of Risk Pooling and Insurance

Planning for successful climate adaptation and insurance, as we have seen above, can gain a lot by learning from illustrative experiences. In the 5 case-studies from Gaza province in Mozambique and Limpopo province in South Africa (under the ADAPTIVE research project) and three national-level efforts in mainstreaming adaptive practices from different programmatic approaches, Osbahr (2008) argues that national adaptation interventions can have positive influences on enhancing local adaptation actions. However, the larger policy question is how can adaptive livelihood strategies and risk-pooling options be best strengthened through institutional actions (through national governments, multilateral donor agencies and international development agencies and local stakeholder organisations), and more importantly, how can local successes be scaled-up, replicated, and made sustainable.

In the case of Mozambique coordinated national food security, agriculture, poverty-reduction and disaster planning policy have lent valuable supportive frameworks for local adaptation strategies. Formal national adaptive policy, such as the National Action Plan for Adaptation [NAPA], could be the ideal platform for coordinated institutional action that builds on local, traditional knowledge systems and social networks: In Malawi, for example, the NAPA prioritises building on 'existing structures and initiatives to improve community resilience to climate change through the development of sustainable rural livelihoods'. Malawi also happens to have a private sector led, pilot initiative (one of the earliest in Africa) for an index-based weather insurance provided directly to smallholders to cope with risks of unreliable water availability, crop failure and food insecurity. It strongly builds on the network of agriculture extension services, and more importantly, stakeholders across the rural society. However, the role of traditional safety nets remains equally important. Firstly, it can be a compensating layer of security for those without land, and secondly, a means of promoting increased yield by tying in with farmers clubs, water-user associations (WUA) etc.

Contemporary experience on climate-induced risks and vulnerability and the ability of exposed populations to successfully manage, cope and insure their livelihoods against these risks will help build a synergistic policy package for the national, regional and local level. Furthermore, the institutional reform needed to make these policies a success should also aim to address the fundamental causes of risk, insecurity and uncertainty, social dynamics and perpetrators of inequality. The possible policy options might involve the following measures in moving towards successful adaptation:

- A broad-based, dynamic approach to vulnerability which does not limit its assessment to ecological and climatic risks, but also incorporates social and economic aspects of vulnerability should be an integral part of cross-national and sub-national assessments of vulnerability to identify priority clusters. Again, such exercises should be made regular to assess and monitor changes in the indicator values over time.
- Develop information systems and capacities for both national and local governments as a part of the NAPAs, as regular, reliable and disaggregated data are at the heart of evidence-based climate risks adaptive policy-making. Again, this should not be limited only for meteorological or climate information, but include socioeconomic information as well, for which existing capacities even at the national level is weak in many countries. These tools should be best interpreted in a multi-disciplinary framework.
- Complement and reinforce local support networks with formal insurance as informal institutions continue to play a crucial role in adapting livelihoods to exogenous stressors, and 'it is critical that new initiatives in any sector do not replace or challenge these systems' (Osbahr, 2008). Both the Malawian example and the HARITA initiative discussed earlier can be useful templates

where formal, market-based insurance products are carefully integrated to a wider basket of integrated actions.

- Ensure wider involvement of stakeholders in all adaptive mechanisms by investing in institutional capacity and promoting local stakeholder groups such as farmers' cooperatives, user associations, church or funeral societies, ethnic groups and community elders. Only a consultative process engaging the different layers and sectors of stakeholders in planning, designing, implementing, monitoring and evaluating interventions can ensure its acceptability, encourage greater participation and instil sustainability.
- Encourage entrepreneurial efforts and facilitate knowledge-sharing as an implicit incentive to tap on innovations that emerge from a confluence of ideas – both indigenous and learning experiments – and ensure that such examples are replicated through suitable forums and channels across larger geographical areas.
- Strengthen local-level capacity to initiate and implement adaptive measures which is a key requirement for making initiatives sustainable and not aid-or donor-driven. Following equally from the above-stated suggestions, this should involve promoting systematic knowledge-sharing to identify priorities, promote rapid and effective uptake of innovative practices, technologies and results.

Appendices

Appendix 11: NM(H)S investment scenarios for provision on services to insurance sector

Scenario	Type of activities
High	• New observations equipment (AWS, automatic rain gauges) • Observer training courses • Installation of maintenance equipment/workshop • Training of engineers in maintenance and calibration of observing equipment • Data transmission modernisation (via mobile/email) to facilitate exchange of real-time data • Meteorological database modernisation • Assess additional hydro-met data collected by different institutions and make recommendations on how to integrate for insurance purposes • Insurance sector service development and training
Medium	• Installation of maintenance equipment/workshop • Training of engineers in maintenance and calibration of observing equipment • Data transmission modernisation (via mobile/email) to facilitate exchange of real-time data • Meteorological database modernisation • Assess additional hydro-met data collected by different institutions and make recommendations on how to integrate for insurance purposes • Insurance sector service development and training
Low	• Assess additional hydro-met data collected by different institutions and make recommendations on how to integrate for insurance purposes • Insurance sector service development and training

Table A11.1: Example investment scenarios and associated activities for NMHS to provide support insurance products

Appendix 12: Analysis of GTS data

Rainfall data from 32 GTS stations (listed in Table A1.1) open during the period 1985 to 2017 were extracted from the Met Office archive.

Station name	Country	Latitude	Longitude
ARBA MINCH	Ethiopia	6.083	37.633
AWASSA	Ethiopia	7.083	38.483
BAHAR DAR	Ethiopia	11.6	37.417
COMBOLCHA	Ethiopia	11.117	39.733
DEBREMARCOS	Ethiopia	10.333	37.667
DIRE DAWA	Ethiopia	9.6	41.85
GODE	Ethiopia	5.9	43.583
GONDAR	Ethiopia	12.533	37.433
GORE	Ethiopia	8.167	35.55
ADDIS ABABA-BOLE	Ethiopia	9.033	38.75
LEKEMTE	Ethiopia	9.083	36.45
MAKELE	Ethiopia	13.5	39.483
MALINDI	Ethiopia	-3.233	40.1
NEGHELLI	Ethiopia	5.283	39.75
GARISSA	Kenya	-0.467	39.633
KERICHO	Kenya	-0.367	35.267
KISUMU	Kenya	-0.1	34.75
KITALE	Kenya	1.017	35
LODWAR	Kenya	3.117	35.617
MAKINDU	Kenya	-2.283	37.833
METEHARA	Kenya	8.867	39.9
MOMBASA	Kenya	-4.033	39.617
NAIROBI/KENYATTA AIRPORT	Kenya	-1.317	36.917
NAROK	Kenya	-1.133	35.833
EMBU	Kenya	-0.5	37.45
VOI	Kenya	-3.4	38.567
WAJIR	Kenya	1.75	40.067
ARUSHA	Tanzania	-3.333	36.617
KILIMANJARO AIRPORT	Tanzania	-3.417	37.067
SAME	Tanzania	-4.083	37.717
TANGA	Tanzania	-5.083	39.067
TORORO	Uganda	0.683	34.167

Table A1.1 Details of GTS stations (+ve Latitude denote N, -ve Latitude denotes S, all Longtiude are W)

The data return for each station was analysed, with the results displayed in Figure A12.1

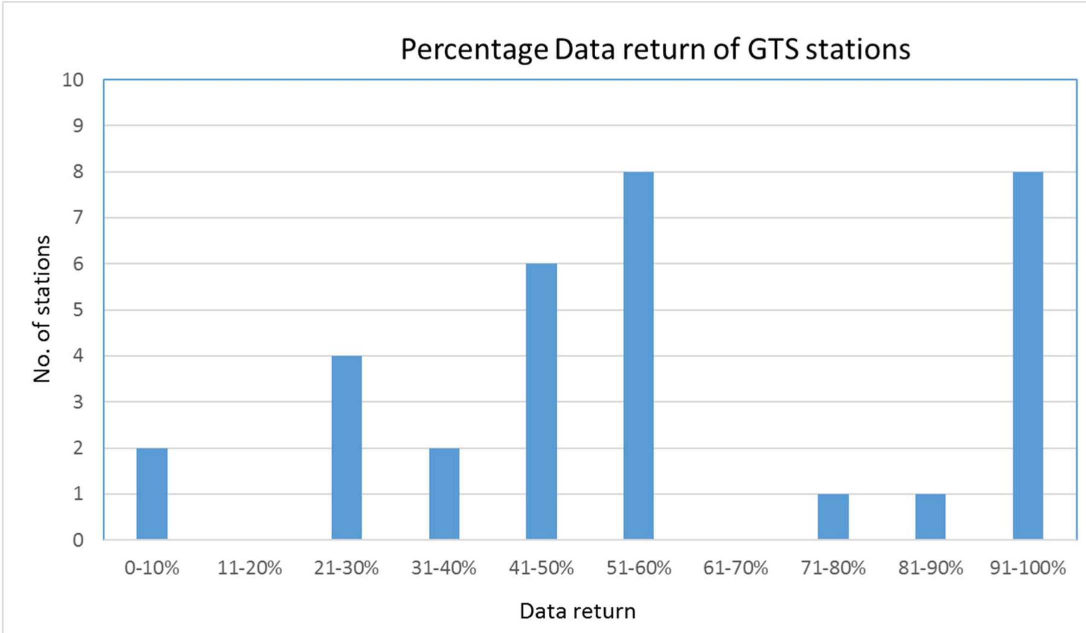

Figure A12.1 Precipitation Data Returns 1985 to 2017

It can be seen that records are variable with 2 stations having only 1-10% of the record. However, nearly one third of the stations had over 71% of the record complete.

A detailed analysis by country has also been undertaken. In the case of Ethiopia (Figure A12.2) it can be seen that the completeness of record has increase from 2006.

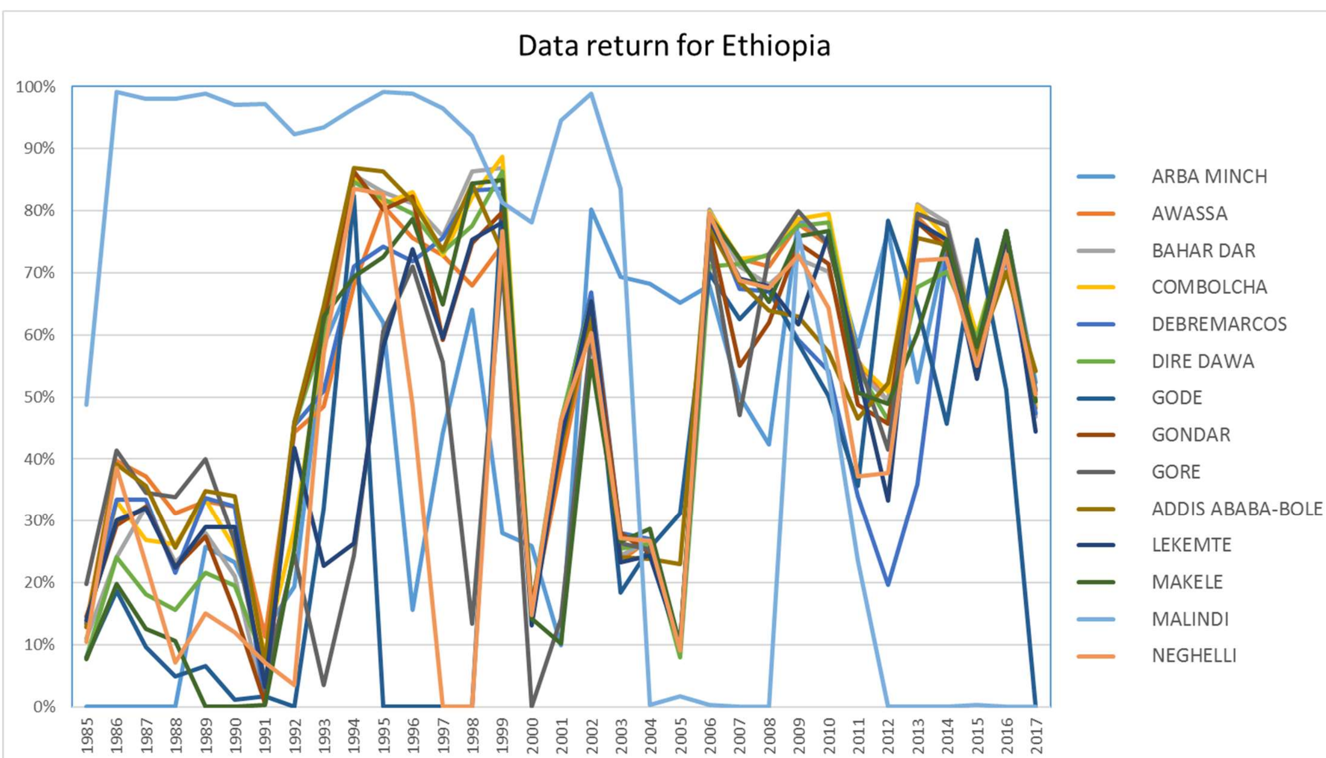

Figure A12.2 Precipitation Data Returns 1985 to 2017 for Ethiopia

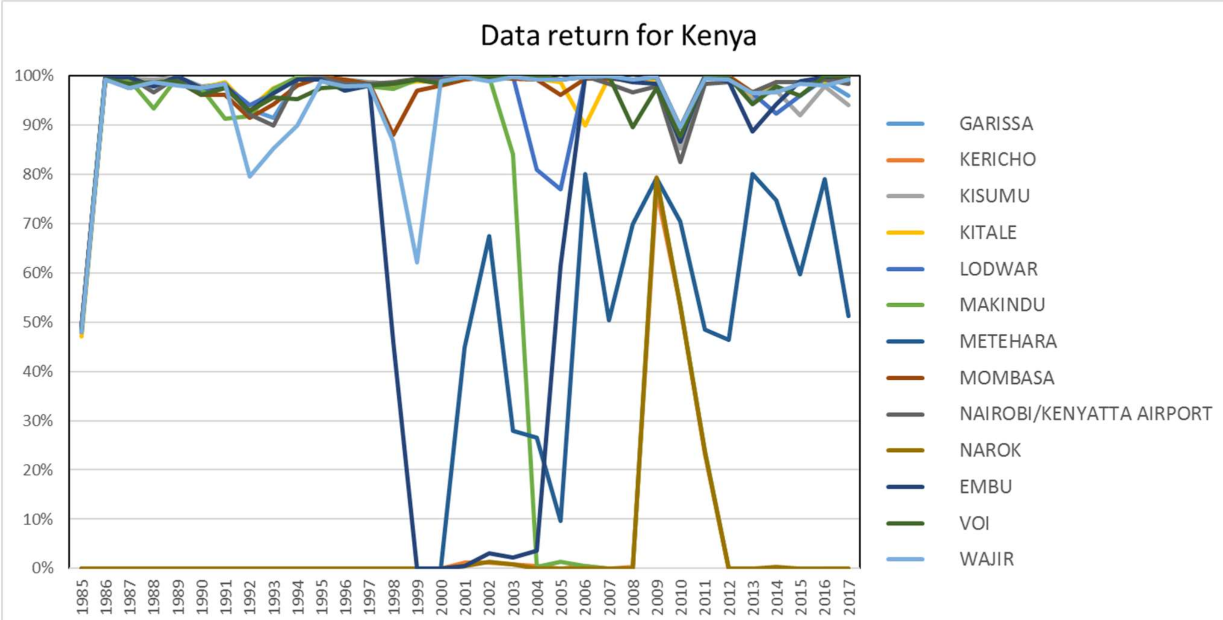

Figure A12.3 Precipitation Data Returns 1985 to 2017 for Kenya

Kenya's data record is high (Figure A12.4) with the exception of 3 stations.

Re

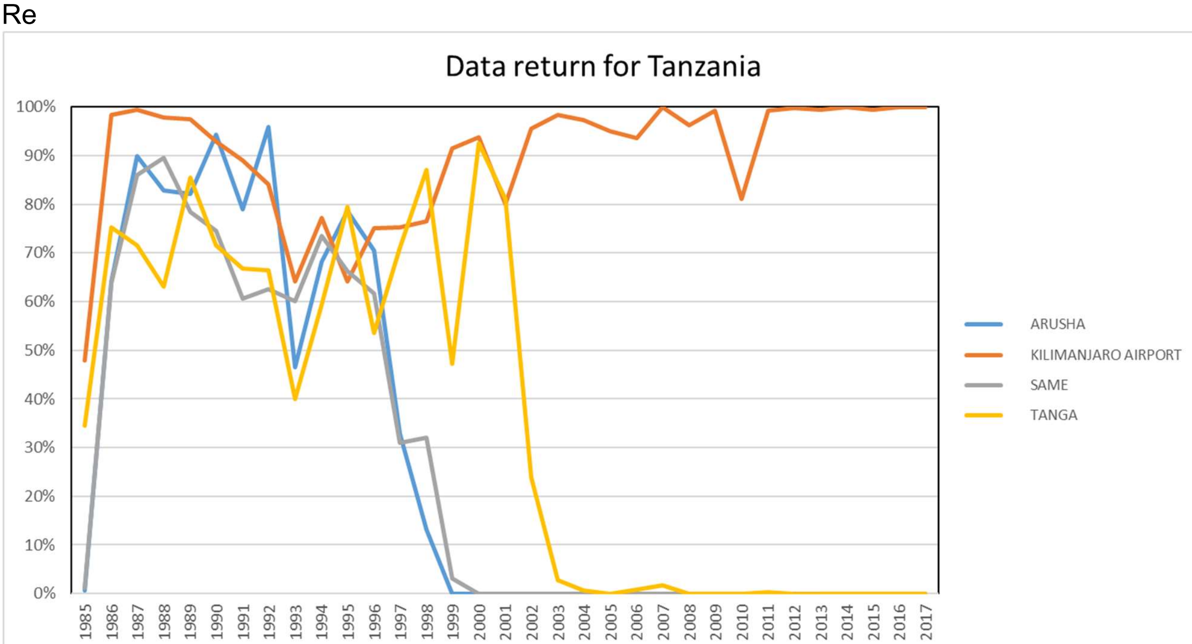

Figure A12.4 Precipitation Data Returns 1985 to 2017 for Tanzania

It can be seen in Figure A12.4 that Tanzania's record is variable with only Kilimanjaro airport having any significant data from 2003 onwards.

It should be stressed that NM(H)S will hold more data in paper form and possibly digital form than is stored in the Met Office archive.

Appendix 13: Examples of satellite products over Africa

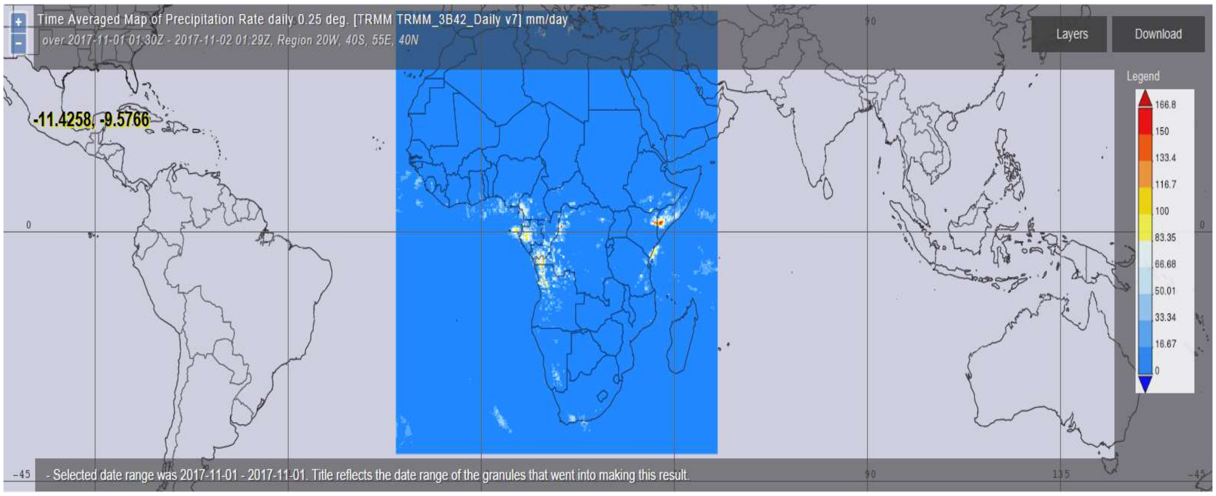

Figure A13.1: Example of TRMM product data (02 November 2017)

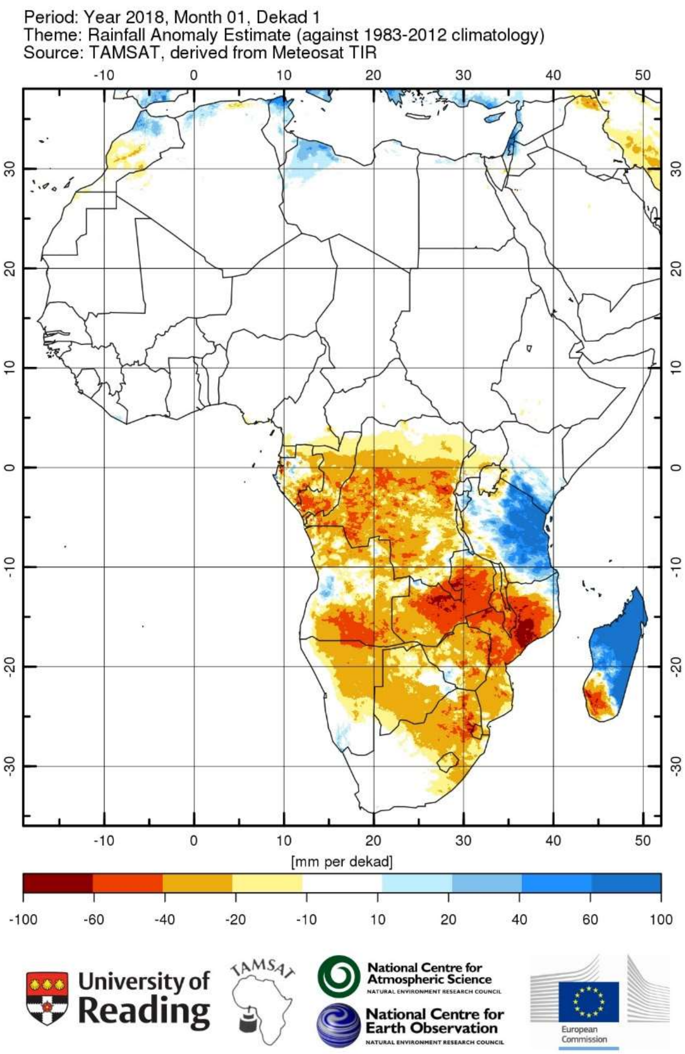

Figure A13.2: TAMSAT 10-day rainfall estimate for January 1st-10th 2018

Annex 14: Summary, explanation and discussion of daily, 10 day and monthly precipitation datasets in Africa

A summary of daily, 10 day and monthly precipitation datasets was produced by David Parker, Elizabeth Good and Rob Chadwick from the Met Office Hadley Centre in February 2012 in support of the Met Office's DFID funded African Climate Science Research Partnership. The suitability of using these data sets for climate monitoring, future attribution, and for forecast evaluation was assessed and the most suitable datasets are shown in green. This summary has been reviewed and updated in March 2018.

When priority countries have been selected and insurance instruments for the pilot phase chosen an assessment can be made of whether these datasets could be used to meet the historic and real time data requirements of the instrument chosen.

DAILY RAINFALL DATASETS

Dataset	Spatial Res.	Spatial Coverage	Temporal Coverage	Variables	Data
GHCN-D	Station	Global	19th C.- present	Total precipitation	Gauge
CPC gauge	0.5°	Global	1979- present	Total precipitation	Gauge
TRMM	0.25°	50°S-50°N	1997- present	Rain rate (mm/day)	Satellite
GPCP	1°	Global	Oct 1996- present	Rain rate (mm/day)	Satellite
GPCP GPI	1°	40°N-40°S	1996- present	Rain rate (mm/day)	Satellite
CMORPH	0.25°	60°N-60°S	2002- present	Rain rate	Satellite
CPC-RFE 2.0	0.1°	40°S-40°N, 20°W-55°E	1995- present	Rain rate (mm/day)	Gauge & satellite
CPC-ARC 2.0	0.1 °	40°S-40°N, 20°W-55°E	1983- present	Rain rate (mm/day)	Gauge & Satellite
CIP	Various	African continent	Prototype	Rain rate (mm/day)	Various
TAMSAT	4km	All Africa Land only	1983- present	Total precipitation & anomaly	Satellite
CHIRPS	0.05°	50°S-50°N	1981- present	Rain rate (mm/day)	Gauge & Satellite

Table A14.1 – (Chapter 4, Section 4.6) Daily precipitation data sets

EXPLANATION OF DAILY PRECIPITATION DATASETS

GHCN-D

The Global Historical Climate Network-Daily (GHCN-D) dataset, maintained by the National Climatic Data Center (NCDC), contains data records for over 100,000 stations in 180 countries and territories. Variables include maximum and minimum daily temperature, temperature at time of observation, daily precipitation totals, snowfall and snow depth. However, about one half of the stations report precipitation only. The data undergo rigorous quality control, the results of which are provided in the ascii data files available via FTP from NCDC.

Coverage of study region: Sparse, with the exception of parts of Southern Africa
Dataset update information: Updated daily in real time.
Further information: https://www.ncdc.noaa.gov/ghcn-daily-description

CPC Gauge-Based Analysis of Global Daily Precipitation

The CPC daily precipitation product is a recent initiative, and is the first stage of long-term plans at the CPC to develop, unify and improve their existing precipitation products. The product is based on gauge measurements, which are quality-controlled and then interpolated onto a grid using optimal interpolation that includes adjustments for topographic effects. Between 1979 and 2005, a retrospective version of the product is available that is based on more than 30,000 gauges. From 2006, a real time version is available that is based on approximately 17,000 gauges. The majority of stations are based in the US, Mexico, South America and Australia, with just 5000 stations originating from outside of these regions. Station network density information is provided with the data products and users are encouraged to consult this when using the data. In addition, a quality check report is provided that lists known problems with the data that have been realised through manual checks.

Coverage of study region: Complete. However, note that the dataset is based on very few stations in Africa, particularly in tropical regions, and therefore has high uncertainty.
Dataset update information: Updated in near real time – lag of 1-2 days.
Further information: https://www.esrl.noaa.gov/psd/data/gridded/data.cpc.globalprecip.html

TRMM (Tropical Rainfall Monitoring Mission) 3B 41 Version 6

The TRMM is a joint satellite project between NASA and JAXA to improve observations of precipitation over the tropics. The mission incorporates several instruments, including a microwave imager, radar and visible-infrared scanner. A number of different products are made available to users, including eight monthly products, one daily and one 3-hourly. The daily product is derived from a combination of TRMM data and other satellite infrared observations (e.g. Meteosat, GMS, GOES and NOAA-12). The TRMM data are used to produce monthly infrared calibration parameters, which are then applied to 3-hourly precipitation estimates from the other satellite infrared datasets. The daily totals are estimated from the 3-hourly precipitation data between 00Z and 21Z. Finally the daily totals are scaled so that the monthly total matches that of the satellite-gauge TRMM. The final dataset consists of a daily precipitation rate and root-mean-square precipitation-error estimates.

Coverage of study region: Complete
Dataset update information: Updated with a few days to a week lag
Further information: http://precip.gsfc.nasa.gov/

GPCP 1DD v1.2

This analysis is largely based on the monthly combined satellite-gauge product which is used to calibrate daily estimates derived from geostationary and polar-orbiting infrared sensors. Microwave and gauge estimates are not used explicitly owing to sampling limitations. The accuracy of GPCP 1DD is expected to be lower than that of the monthly dataset.

Coverage of study region: Complete
Dataset update information: Updated with a few months delay.
Further information: http://precip.gsfc.nasa.gov/gpcp_daily_comb.html.

GPCP GPI

The GPCP GOES Precipitation Index (GPI) is one of the elements that is used in the GPCP daily precipitation estimates. This dataset is based solely on infrared observations from geostationary satellite platforms. The approach used to produce the GPI is extremely simple, and is expressed as:
Precipitation (mm) = FRAC x RATE x TIME. Where 'FRAC' is the fractional coverage of infrared pixels with top of atmosphere brightness temperature of less than 235K over a reasonably large domain (50 km x 50 km and larger), 'RATE' is 3 mm/hour, and 'TIME' is the number of hours over which "FRAC" was compiled.

Coverage of study region: Complete
Dataset update information: Updated monthly.
Further information: http://www.cpc.ncep.noaa.gov/products/global_precip/html/wpage.gpi.shtml.

CMORPH

The CPC MORPHing technique (CMORPH) precipitation estimates are derived principally from passive microwave observations of precipitation from polar-orbiting platforms. Geostationary infrared data are then used to provide supplementary high-resolution information, 'propagating' the microwave estimates through both space and time, allowing precipitation rates to be estimated at a frequency of 30 minutes and at 8 km spatial resolution. The 30-minute data are then aggregated to provide 3-hourly estimates, which in turn are used to derive the daily estimates. At present, microwave data from SSM/I, AMSU-B, AMSR-E and TMI are used in the analysis. The objective of CMORPH is to provide a method of combining different microwave retrievals from different sources; CMORPH is not explicitly a precipitation retrieval algorithm in its own right.

Coverage of study region: Complete
Dataset update information: Updated in near real time with a couple of days lag. Note: only the last few weeks of daily data are archived by CPC. For older data, the user must retrieve the three-hourly data and aggregate.
Further information: http://www.cpc.ncep.noaa.gov/products/janowiak/cmorph_description.html
https://climatedataguide.ucar.edu/climate-data/cmorph-cpc-morphing-technique-high-resolution-precipitation-60s-60n

CPC Africa RFE (FEWS-NET)

The CPC African Rainfall Estimate (RFE) is a combined gauge-satellite precipitation dataset and has been developed as part of the Famine Early Warning System Network (FEWS-NET) project. Operational and climatological versions of the estimates are produced using different (though similar) methodologies. The operational product went through a major change in 2001, from V1.0 to V2.0.

V1.0 of the operational product covers the period 1995-2000, while V2.0 is from 2001 to the present. The V2.0 dataset shares many similarities with the CMAP product, described in Section A2.3.12. In essence, a combined satellite dataset is generated from microwave AMSU and SSM/I, and GPI precipitation estimates using a maximum likelihood method. These are then merged with daily rain gauge data from up to 1000 stations, although typically, the number of stations is closer to 500 owing to erroneous station data and/or poor station maintenance. The merging process allows the final rainfall estimates to have the magnitude of the station data, with the shape of the precipitation field determined by the satellite estimates.

There are significant differences between RFE 2.0 and 1.0, leading to possible biases in the combined operational time series. RFE 1.0 does not include microwave data, but instead has a separate component for estimating orographic rainfall based on model humidity and wind fields combined with orography data.

The climatological version of RFE (African Rainfall Climatology (ARC)) covers 1983 to the present, and is continually updated. ARC 1.0 was similar to the operational RFE 1.0 product, combining GPI estimates with available gauge data, but does not include an orographic rainfall element. Microwave estimates are not included due to the shorter time period of available microwave observations compared to infrared data. However the number and position of gauges included in the analysis varies over time, which may introduce biases into the analysis (Yin and Gruber (2010))[54].

ARC 2.0 was produced it is a revision of the first version of the ARC. Consistent with the operational Rainfall Estimation, version 2, algorithm (RFE2), ARC2 uses inputs from two sources: 1) 3-hourly geostationary infrared (IR) data centred over Africa from the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and 2) quality controlled Global Telecommunication System (GTS) gauge observations reporting 24-h rainfall accumulations over Africa. The main difference with ARC1 resides in the recalibration of all Meteosat First Generation (MFG) IR data (1983–2005).

RFE 2.0 and ARC 2.0 climatological estimates are available at various temporal resolutions, including daily, 10-day, monthly and seasonal composites.

Coverage of study region: Complete
Dataset update information: Updated in near real time – lag of 1-2 days.
Further information: http://www.cpc.noaa.gov/products/fews/RFE2.0_tech.pdf,
http://www.cpc.ncep.noaa.gov/products/fews/AFR_CLIM/arc2_201303_final.pdf,
http://www.cpc.ncep.noaa.gov/products/international/africa/africa.shtml

CIP

Climate Information Platform (CIP) is a web interface that integrates two important information sources into one easy to use interface. The first important source is a climate database that stores and manages queries to a large suite of observational climate data as well as projections of future climate. The second important source of information is an extensive collection of guidance documentation that facilitates the best use of the climate data, it's interpretation and, importantly, resultant actions. The philosophy guiding CIP is that data is not information and as such only has value when well interpreted and correctly used or applied to appropriate problems.

CIP is targeted at a wide range of users. CIP has been designed to be easy and intuitive to use so as to provide easy and simple access to various climate information. However, CIP has also been designed to offer important features such as data downloads that suite users more familiar with climate data. It is our hope that as CIP develops, and you the user provides us with feedback, we will continue to satisfy the needs of a wide range of users.

Coverage of study region: Complete
Dataset update information: Currently a prototype
Further information: http://cip.csag.uct.ac.za/webclient2/app/

54 Yin, X and A. Gruber, 2010. Validation of abrupt changes in GPCP precipitation in Congo River Basin *Int. J. Climatol*., **30**, 110–119. doi: 10.1002/joc.1875 22/

TAMSAT

The TAMSAT (Tropical Applications of Meteorology using SATellite data) product produces daily rainfall estimates for all of Africa at 4km resolution. The TAMSAT archive spans 1983 to the delayed present. The longevity of the dataset makes it especially suitable for risk assessment. Applications of the data include famine early warning, drought insurance and agricultural decision support.

Rainfall estimates and other TAMSAT products are issued on the 1st, 6th, 11th, 16th, 21st, and 26th of the month.

It covers the whole African continent using infrared data only from the Meteosat series of satellites and is therefore likely to be more consistent over long periods than datasets compiled from multiple sources and satellites. It uses a simple linear relationship between cold cloud amount and rainfall similar to that used by the GPI but is calibrated specifically for Africa with different fixed calibrations used regionally and seasonally. Historical rain-gauge data are used to calibrate the product but real-time gauge data are not needed to produce the estimates.

TAMSAT are available at daily, 5 day, 10-day, monthly and seasonal temporal resolutions.

Coverage of study region: Complete
Dataset update information: Every 5 days
Further information: https://www.tamsat.org.uk/about

CHIRPS

Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) is a 30+ year quasi-global rainfall dataset. Spanning 50°S-50°N (and all longitudes), starting in 1981 to near-present, CHIRPS incorporates 0.05° resolution satellite imagery with in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring. As of February 12th, 2015, version 2.0 of CHIRPS was complete and available to the public.

Two CHIRPS products are produced operationally: a rapid preliminary version, and a later final version. The preliminary CHIRPS product is available, for the entire domain, two days after the end of a pentad (2nd, 7th, 12th, 17th, 22nd and 27th). The preliminary CHIRPS uses two station sources, GTS and Mexico.

The final CHIRPS product takes advantage of several other stations sources and is complete sometime in the third week of the following month. Final products for all times/domains/formats are calculated at that time.

Coverage of study region: Complete
Dataset update information: Initial every 5 days, final monthly
Further information: http://chg.geog.ucsb.edu/data/chirps/#plus3

Discussion of daily precipitation datasets

There are significant differences between available daily precipitation datasets. Care should be taken when using gauge only datasets since they are based on so few *in situ* measurements. The authors of the CPC dataset, for example, specifically point out that the quality of their gauge-analysis is poor over Africa. They recommend interpreting their precipitation analysis in conjunction with the gauge density information that is supplied in the product to indicate where confidence is particularly low/high. Roca *et al*. (2010)[55] discuss the sampling uncertainties of both rain-gauge and satellite estimates of precipitation.

The authors recommend satellite only or satellite-gauge for the purposes of forecast evaluation and attribution

A good choice of satellite-only products would appear to be TRMM and TAMSAT. Of the combined satellite-gauge products, the operational RFE 2.0 is recommended for forecast validation, while ARC 2.0 is probably more appropriate for attribution studies, due to its longer record, though it may have biases owing to the varying number of gauges included in the analysis. The poor quantitative performance of all current satellite rainfall products at high spatial resolution on daily scales should be kept in mind. Averaging these products to larger spatial scales is expected to improve their accuracy.

10 DAY PRECIPITATION DATASETS

Dataset	Spatial Res.	Spatial Coverage	Temporal Coverage	Variables	Data
GHCN-D	Station	Global	19th C.-present	Total precipitation	Gauge
CPC gauge	0.5°	Global	1979-present	Total precipitation	Gauge
TRMM	0.25°	50°S-50°N	1997-present	Rain rate (mm/day)	Satellite
GPCP	1°	Global	1996-present	Rain rate (mm/day)	Satellite
GPCP GPI	1°	40°N-40°S	1996-present	Rain rate (mm/day)	Satellite
CMORPH	0.25°º	60°N-60°S	2002-present	Rain rate (mm/day)	Satellite
CPC-RFE 2.0	0.1°	40°S-40°N, 20°W-55°E	1995-present	Rain rate (mm/day)	Gauge & satellite
CPC-ARC 2.0	0.1°	40°S-40°N, 20°W-55°E	1983-present	Rain rate (mm/day)	Gauge & satellite
TAMSAT	4km	All Africa Land only	1983-present	Total precipitation & anomaly	Satellite
CHIRPS	0.05°	50°S-50°N	1981-present	Rain rate (mm/day)	Gauge & Satellite

Table A14.2– (Chapter 4, Section 4.6) Summary of 10-day precipitation dataset availability

EXPLANATION OF 10 DAY PRECIPITATION DATASETS

Please see explanation of daily precipitation datasets

DISCUSSION OF 10 DAY PRECIPITATION DATASETS

[55] Roca, R., P. Chambon, I. Jobard, P.-E. Kirstetter, M. Gosset and J.C. Bergès, 2010: Comparing Satellite and Surface Rainfall Products over West Africa at Meteorologically Relevant Scales during the AMMA campaign using error estimates. *J.Appl Meteorol and Climatol., 49 715-731*

10-day rainfall estimates are key for forecasting and attribution where sub-monthly information is required, and where daily datasets do not provide sufficient accuracy or reliability.

The sparsity of reporting gauges in most of Africa means that satellite-only and combined gauge-satellite datasets are preferable to gauge-only datasets. For forecast verification, intercomparison studies indicate that of the satellite-only products, TAMSAT and TRMM may be the best, while the operational RFE 2.0 is the most suitable combined gauge-satellite product. For attribution studies, the TAMSAT and climatological RFE datasets are most appropriate; TAMSAT may be more consistent over time as RFE includes a gauge component of varying spatial coverage.

Validation studies (Dinku *et al.* 2007[56]; Jobard *et al.* 2007[57]) show the value of local calibration or constraint of satellite rainfall products, either with gauges (TAMSAT and RFE) or precipitation radar (TRMM). This is also likely to apply to other timescales.

MONTHLY PRECIPITATION DATASETS

Dataset	Spatial Res.	Spatial Coverage	Temporal Coverage	Variables	Data
GHCN	Station	Global	19th C-present	Precip total.	Gauge
GPCC first guess	1.0° & 2.5°	Global	Oct 2003 - present	Precip total	Gauge
GPCC monitoring	1.0° & 2.5°	Global	1986-present	Precip total	Gauge
GPCC reanalysis	0.5°, 1.0° & 2.5°	Global	1901 - 2013	Precip total & anomaly.	Gauge
GPCC VASClimO	0.5°, 1.0° & 2.5°	Global	1951 - 2000	Precip total	Gauge
GPCC gridded climatology	0.25°, 0.5°, 1.0° & 2.5°	Global	1951 - 2000	Precip total	Gauge
CRU	0.5º	Global	1901-2016	Precip total, wet-day frequency	Gauge
University of Delaware	0. 5º	Global	1900-2008	Precip total.	Gauge
NCDC	5º	Global	1900-present	Precip anomalies	Gauge
GPCP	2.5º	Global	1979-present	Rain rate (mm/day)	Gauge & satellite
CMAP	2.5º	Global	1979-present	Rain rate (mm/day)	Gauge & satellite & model
TRMM	0.25º	50°S-50°N	1998-present	Rain rate (mm/hour)	Gauge & satellite

[56] Dinku, T., P. Ceccato, E. Grover-Kopec, M. Lemma, S. Connor, and C. Ropelewski, 2007: Validation of satellite rainfall products of East Africa's complex topography. *Int.J Remote Sensing. 28 (7) 1503,1526.*

[57] Jobard, I., F. Chopin, J. Bergès, A. Ali, T. Lebel, and M. Desbois, 2007: Presentation of the EPSAT-SG method and comparison with other satellite precipitation estimations in the frame of precipitation AMMA. In EGU conference proceedings, Vienna 15-20 April 2007

Dataset	Spatial Res.	Spatial Coverage	Temporal Coverage	Variables	Data
CAMS-OPI	2.5º	Global	1979-present	Rain rate (mm/day)	Gauge & satellite
CPC-RFE 2.0	0.1°	40°S-40°N, 20°W-55°E	1995-present	Rain rate (mm/day)	Gauge & satellite
CPC-ARC 2.0	0.1°	40°S-40°N, 20°W-55°E	1983-present	Rain rate (mm/day)	Gauge & satellite
TAMSAT	4km	All Africa Land only	1983-present	Precip total & anomaly	Satellite
CHIRPS	0.05°	50°S-50°N	1981-present	Rain rate (mm/day)	Gauge & Satellite
ENACTS	Various	Selected countries	Various	Precip total	Gauge & Satellite

Table A14.3 – (Chapter 4, Section 4.6) Summary of monthly precipitation dataset availability

EXPLANATION OF MONTHLY PRECIPITATION DATASETS

GHCN

GHCN contains more than 20,000 stations across the globe that report monthly precipitation. The data undergo rigorous quality control.

Coverage of study region: Patchy: varies from reasonable to very poor
Dataset update information: Updated monthly in real time.
Further information: http://www.ncdc.noaa.gov/ghcnm/

GPCC – First Guess

The GPCC produces several global precipitation products. The first guess product is a provisional product based on SYNOP reports from about 6000 stations worldwide and is available in near-real time. The data are subject to automated quality control before being included in the analysis. This dataset is derived from station anomalies, which are calculated with respect to the GPCC global normals. Once gridded, the anomalies are superimposed on the gridded climatology before being released to users. The first guess product is considered to be the least accurate of the GPCC products, as the other products undergo more extensive pre-processing and quality control. Users are encouraged to consult the gauge density information supplied with the gridded product.

Coverage of study region: Complete, but derived from very few gauges
Dataset update information: Available within 5 days of the end of the month.
Further information: http://gpcc.dwd.de

GPCC – Monitoring

The GPCC monitoring product is based on SYNOP and CLIMAT reports from 7000-8000 stations. It is similar to the first guess product but uses additional stations and more rigorous quality control that involves both automatic and manual methods. Like the first guess product, the dataset is based on station anomalies that are gridded and then superimposed on the climatology to produce gridded total precipitation. Gauge density information is supplied with the precipitation data. From 2007, both absolute and relative (%) error fields are also available in the data files. The GPCC monitoring product constitutes the *in situ* component of both the GPCP and CMAP analyses.

Coverage of study region: Complete, although gauge network is sparse in some regions so product may be unreliable in places
Dataset update information: Available within about two months after the end of the month.

Further information: ftp://ftp.dwd.de/pub/data/gpcc/html/gpcc_monitoring_v5_doi_download.html

GPCC – Reanalysis (v4)

The GPCC reanalysis product is more accurate than the first guess and monitoring products. It is optimised to achieve maximum spatial coverage and is based on quality-controlled data from all available station records in the GPCC data base, including both real-time and non real-time data. Coverage ranges between less than 10,000 and about 45,000 stations. The analysis method is essentially the same as for the first guess and monitoring products and does not use a physical model. The data files include both anomalies and actuals, along with the number of gauges per grid cell. GPCC recommends that the gauge density information is consulted in conjunction with the precipitation data.

Coverage of study region: Complete, may be unreliable where gauges are sparse
Dataset update information: Essentially static, updated occasionally.
Further information: ftp://ftp.dwd.de/pub/data/gpcc/html/fulldata_v7_doi_download.html

GPCC – 50-year VASClimO (V1.1)

GPCC also product VASClimo, a 50 year dataset that is optimised for temporal analysis of rainfall patterns (e.g. trends). This dataset is based on about 9400 stations' records that have undergone rigorous quality control and homogenisation. Unlike the other GPCC products, gauge density is not explicitly provided within the data files. However, a grid density file and monthly 'Jack-knife-error' estimates are provided for the 0.5-degree grid are provided in separate files. The Jack-knife error is the difference of the interpolated value of the location of the nearest station (taking only other stations into account) and the observation at that station. This therefore provides some estimate of the grid cell error.

Coverage of study region: Complete, although gauge network is sparse in some regions so product may be unreliable in place
Dataset update information: Static
Further information: ftp://ftp.dwd.de/pub/data/gpcc/html/vasclimo_download.htm

GPCC – Gridded Climatology Normals

The final product available from the GPCC is the Gridded Climatology Normals Product which is based on monthly station means between 1951 and 2000 from approximately 64,000 stations. Where stations do not cover the entire 50-year period, 30-year periods are used (e.g. 1961-1990 or 1971-2000) with at least 20 years of available data. Where data covering a 30-year period are unavailable, 10 years of data from any other period is used.

Coverage of study region: Complete, although gauge network is sparse in some regions so product may be unreliable in places.
Dataset update information: Static.
Further information: ftp://ftp.dwd.de/pub/data/gpcc/html/gpcc_normals_v2015_doi_download.html

CRU

The Climate Research Unit (CRU), University of East Anglia TS v. 4.01 dataset is based on records provided by more than 4000 stations from around the world. The station records were sourced from several sources; quality control of the station records was carried out by the station data providers. Before interpolating to 0.5º spatial resolution, the data were converted to anomalies with respect to the 1961-1990 baseline period.
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Coverage of study region: Complete but data may be unreliable where station density is low. Users are advised to check station density information supplied with dataset.

Dataset update information: Essentially static, with a new version released every few years
Further information: https://crudata.uea.ac.uk/cru/data/hrg/

University of Delaware (v2.01)

The University of Delaware gridded precipitation data is based on station observations from a number of different sources, including GHCN. Over Africa, data were also sourced from 'Sharon Nicholson's archive of African precipitation data' (second internet reference below), which contains 1,338 station records between 1950 and 1996. The total number of global stations used in the analysis varies between about 4,100 and 22,000. The method employed for generating the final gridded product is essentially the same as that used for air temperature. The gridded dataset is produced through interpolation of station anomalies (in mm, not %), which are then combined with an equivalent gridded climatology to produce estimates of the absolute mean monthly precipitation. The dataset includes interpolation error estimates derived from the results of cross validation experiments.

Coverage of study region: 100% coverage of global land. However, note, where station density is low the data are heavily interpolated and may be unreliable.

Dataset update information: Infrequently updated – essentially static. Further information:
http://climate.geog.udel.edu/~climate/html_pages/Global2_Ts_2009/README.global_p_ts_2009.html
http://climate.geog.udel.edu/~climate/html_pages/Tropics_files/README.tropic_precip_ts.html

NCDC

Like the NCDC gridded air temperatures, the gridded precipitation product is derived from GHCN station data. Data from approximately 22,000 stations are used in the analysis; homogenised records (from the U.S., Canada, and Former Soviet Union) are used in preference to the 'raw' station records. The data set is an anomaly data set, reference to the baseline period 1961-1990. Station anomalies are gridded by averaging values recorded within each grid box.

Coverage of study region: Poor
Data set update information: Updated monthly to include most recent month.
Further information: https://www.ncdc.noaa.gov/temp-and-precip/ghcn-gridded-products/

GPCP (v2.3)

The GPCP Monthly product provides a consistent analysis of global precipitation from an integration of various satellite data sets over land and ocean and a gauge analysis over land. Data from rain gauge stations, satellites, and sounding observations have been merged to estimate monthly rainfall on a 2.5-degree global grid from 1979 to the present. Long term monthly means, derived from years 1981 - 2010. The careful combination of satellite-based rainfall estimates provides the most complete analysis of rainfall available to date over the global oceans, and adds necessary spatial detail to the rainfall analyses over land. In addition to the combination of these data sets, estimates of the uncertainties in the rainfall analysis are provided as a part of the GPCP products.

Coverage of study region: Complete
Dataset update information: Updated with a few months delay
Further information: https://www.esrl.noaa.gov/psd/data/gridded/data.gpcp.html

CMAP

The monthly data set consists of two files containing monthly averaged precipitation rate values. Values are obtained from 5 kinds of satellite estimates (GPI,OPI,SSM/I scattering, SSM/I emission and MSU) and gauge data. The enhanced file also includes blended NCEP/NCAR Reanalysis Precipitation values. The other just includes the satellite estimates and gauge data. Pentad data are also available.

This data set consists of monthly averaged precipitation rate values (mm/day).

Coverage of study region: Complete
Dataset update information: Irregular, not real time
Further information: https://www.esrl.noaa.gov/psd/data/gridded/data.cmap.html#detail

TRMM Combination 3B 43 V.7

The TRMM combination monthly product is a combination of the 3 hourly TRMM 3B 42 precipitation estimates and gauge analyses from the GPCC and Climate Assessment and Monitoring System (CAMS). The gauge data are used first to bias-correct the satellite data fields and then, during merging with the satellite data, to provide the final product using inverse error variance weighting. The product includes RMS error estimates.

Coverage of study region: Complete
Dataset update information: Updated about two weeks after the end of each month.
Further information: https://disc.gsfc.nasa.gov/datasets/TRMM_3B43_V7/summary

CAMS-OPI

The Climate Anomaly Monitoring System (CAMS) and OLR precipitation index (OPI) (CAMS-OPI) product is another precipitation dataset originating from the CPC. The product is comparable with the GPCP and CMAP monthly products, in that it combines both satellite and gauge precipitation estimates. However, unlike these products, which are available after a few months' delay, the CAMS-OPI is updated in near-real time. As the name suggests, the analysis involves gauge data from the CAMS and satellite precipitation estimates from the outgoing longwave radiation (OLR) Precipitation Index (OPI) developed by Xie and Arkin (1998)[58]. The merging technique is similar to that used for CMAP. The CAMS-OPI analysis is primarily designed for real-time monitoring and that users wishing to source data for research purposes should focus on the GPCP and/or CMAP. These datasets are better quality-controlled and include both satellite microwave and infrared estimates of precipitation. The data files made publicly available include the combined analysis, CAMS-only and OPI-only analyses, and the CAMS gauge density.

Coverage of study region: Complete for combined satellite only analysis. Incomplete for CAMS only analysis
Dataset update information: Updated in near real-time. Previous month available shortly before the end of the month.
Further information: http://www.cpc.ncep.noaa.gov/products/global_precip/html/wpage.cams_opi.html

CPC Africa RFE 2.0 (FEWS NET)

Dataset is produced from composite of the daily RFE dataset.

TAMSAT

Dataset is produced by aggregating the 10 day rainfall information.

[58] Xie, P. and P.A Arkin 1998. Global monthly precipitation estimates from satellite-observed outgoing longwave radiation, *J. Climate*, **11**, 137-164**.**

ENACTS

The Enhancing National Climate Services initiative (ENACTS) is led by the International Research Institute for Climate and Society (IRI). One major issue in Africa (and in fact in many other countries) is the declining number of weather stations, their sparseness and uneven distribution. ENACTS provides readily accessible climate data at high resolution (4 – 10 km) to decision makers across many countries in Africa. Countries which are part of ENACTS are Ethiopia, Ghana, Kenya, Madagascar, Mali, Rwanda, Tanzania and Zambia. ENACTS was launched in Uganda in October 2016.

Gridded temperature and rainfall data for each country are created by combining surface gauge and weather station observations with larger-scale climate data. Briefly, differences between satellite estimates and surface gauges / weather stations are calculated for all gauges. Next, these differences are interpolated to a regular grid using inverse distance weighting. Finally, the interpolated differences are added to the satellite data to create the combined product.

For temperature, a reanalysis product is used. The time periods of the temperature and rainfall data vary between countries and the variables. For example, the map room for Kenya has data for 1981-2014 (temperature) and 1983-2014 (rainfall). For rainfall, data from TAMSAT (a satellite product) are used. TAMSAT begins in 1983; hence, for rainfall data, gridded data are only available for 1983-2014. For Tanzania, a gridded temperature dataset was created by combining surface observations with 1 km MODIS data for 2003-2011 and digital elevation data. In Rwanda, temperatures from a reanalysis product were downscaled and combined with surface observations to create the gridded product. The reanalysis product used is unclear; the text states JRA55 was used but the figure titles say MERRA.

ENACTS provides high-resolution gridded data for a number of African countries. It uses data from many gauges which are not reported via the WMO GTS. For example, in Ethiopia, rainfall data from 17 gauges are reported via the GTS, whereas ENACTS has accessed data from over 600 stations. Additional rain gauges are present in Ethiopia but were not used in ENACTS. Similarly, in Tanzania, ENACTS has used rainfall data from many gauges which are not reported via the WMO to create gridded rainfall data. A similar situation exists for reports of surface air temperatures.

ENACTS climate data do not appear to have been updated beyond 2014, based on accessing the various country map rooms. Access to the underlying gauge and weather station data is not straightforward; no links are provided via the map rooms or the ENACTS main pages. The IRI data library does not include the raw station data. Different satellite and reanalysis data appear to have been used for different countries The map room for Rwanda briefly describes the creation of gridded temperatures from surface observations and two different reanalyses, but it is unclear which was used. The text mentions JRA55 but all the figures are titled MERRA. The temperatures shown appear to be 2m air temperature (TAS), but it is unclear whether they are TAS or LST (the MERRA data page only provides TAS; LST is not mentioned). The method used to downscale the MERRA data from 50 km to 5 km is not described.

The methods used to merge and interpolate the station data with satellite data and other proxies appear to differ between countries. The description of creation of gridded data for Ethiopia states that simple bias adjustment was used, whereas the paper describing ENACTS for Tanzania states that regression kriging was used.

Coverage of study region: Ethiopia, Ghana, Kenya, Madagascar, Mali, Rwanda, Tanzania, Zambia and Uganda
Dataset update information: Variable
Further information: https://iri.columbia.edu/resources/enacts/

Discussion of monthly data sets

Over the southern Sahel, a rain-gauge density of at least 10 gauges per 2.5° grid box is required to give a monthly precipitation error of less than 10%. The requirement exceeds 20 gauges per 2.5° gridbox in the Northern Sahel where rainfall is less coherent. (Ali *et al.* (2005)[59]

The gauge density needed for a given percentage monthly precipitation error elsewhere in Africa depends on the spatial coherence of monthly rainfall. Mountainous areas (e.g. most of East Africa) and all zones on the edge of monsoon penetration (e.g. parts of the Sudan, Namibia etc.) are likely to have highly intermittent, patchy rainfall, so it is likely that >20 gauges will be needed per 2.5° grid box, and even more for 10-day rainfall which suffers from greater, less coherent variations. These requirements are very rarely met in available data for Africa, so in general monthly gauge errors are likely to be much larger than 10%. Therefore improvement of *in situ* data availability is an important objective. This applies for monthly and longer timescales because attribution and seasonal hindcast studies need *in situ* rainfall data predating the satellite era. But satellite-era gauge data are also needed, because the validation studies show the value of local calibration or constraint of satellite rainfall products.

Release of monthly data will benefit stakeholders in that long-term trends and their causes can be better assessed; release of daily data will benefit them in that nationally-applicable satellite-based algorithms can be developed and applied to monitoring, studies of extremes, and seasonal forecast verification.

Regarding currently available gauge data, the University of Delaware dataset benefits from the inclusion of Sharon Nicholson's gauge data for 1950-1996. She has extensive links with African NM(H)S and it is likely that her gauge dataset contains a large number of gauges that have not been included in other datasets. For future development, the University of Cape Town data base includes a dense network for South Africa. At present, the GPCC first guess is recommended for near real time, and the University of Delaware, GPCC reanalysis or GPCC-VASClimO for historical analysis.

Owing to sparsity of available gauge data, it is recommended that, at present, datasets with a satellite component should usually be used on gauge only observations. However Yin and Gruber (2010)[60] demonstrate that even blended satellite-*in situ* datasets may suffer biases owing to changes of *in situ* gauge coverage. Of the satellite-gauge datasets, CMAP and GPCP are long enough and may be sufficiently stable for historical analysis. CMAP is reported to agree well with the GPCP merged analysis over land, and tropical and subtropical oceanic areas, but with some differences over extratropical oceans (Xie and Arkin (1997)). TAMSAT appears to be the best option for a historical satellite-only dataset. For near-real time applications RFE 2.0 , TAMSAT or TRMM are recommended.

[59] Ali A., A. Amani, A. Diedhiou, and T. Lebel, 2005: Rainfall estimation in the Sahel. Part 2. Evaluation of rain gauge network in the CILSS countries and objective intercomparison of rainfall products. *J Appl. Meteorol., 44, 1707-1722*

[60] Yin, X and A. Gruber, 2010. Validation of abrupt changes in GPCP precipitation in Congo River Basin *Int. J. Climatol*., **30**, 110–119. doi: 10.1002/joc.1875 22/