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# UNDP MARKET ASSESSMENT

# Revenue-Generating Opportunities Through Tailored Weather Information Products

**UNDP's continental-scale market assessment explores market forces, imperatives, trends and stakeholder needs in the creation of new revenue-generating opportunities for Africa's National Hydro-Meteorological Services (NHMS). The study indicates an increase in the availability and sophistication of weather information, strong demand from private and public customers across a wide range of economic sectors, including agriculture, mining, forestry, construction, aviation, tourism, energy and planning, and a highly competitive business environment, where new ventures will be strongly dependent on highly specialized skills in product development and marketing.**

## March 2016

### UNDP's Programme on Climate Information for Resilient Development in Africa (CIRDA)

**This market assessment was produced by C4 EcoSolutions Pty (Ltd) and commissioned by UNDP through the CIRDA Programme with financing from the Global Environment Facility's Least Developed Countries Fund**

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United Nations Development Programme

ENVIRONMENT AND ENERGY

# ABOUT THIS MARKET ASSESSMENT

**UNDP** partners with people at all levels of society to help build nations that can withstand crisis, and drive and sustain the kind of growth that improves the quality of life for everyone. On the ground in 177 countries and territories, we offer global perspective and local insight to help empower lives and build resilient nations. www.undp.org

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**C4 EcoSolutions** is a company of 15 climate change consultants that develops innovative, evidence-based solutions for adapting to climate change. C4 operates in more than forty countries across Asia and Africa. The company's clients include the International Finance Corporation (IFC), UNEP, IFAD, FAO, CarbonPlus Capital and UNDP. C4's work includes designing and implementing adaptation projects and investments in both the public and private sectors.

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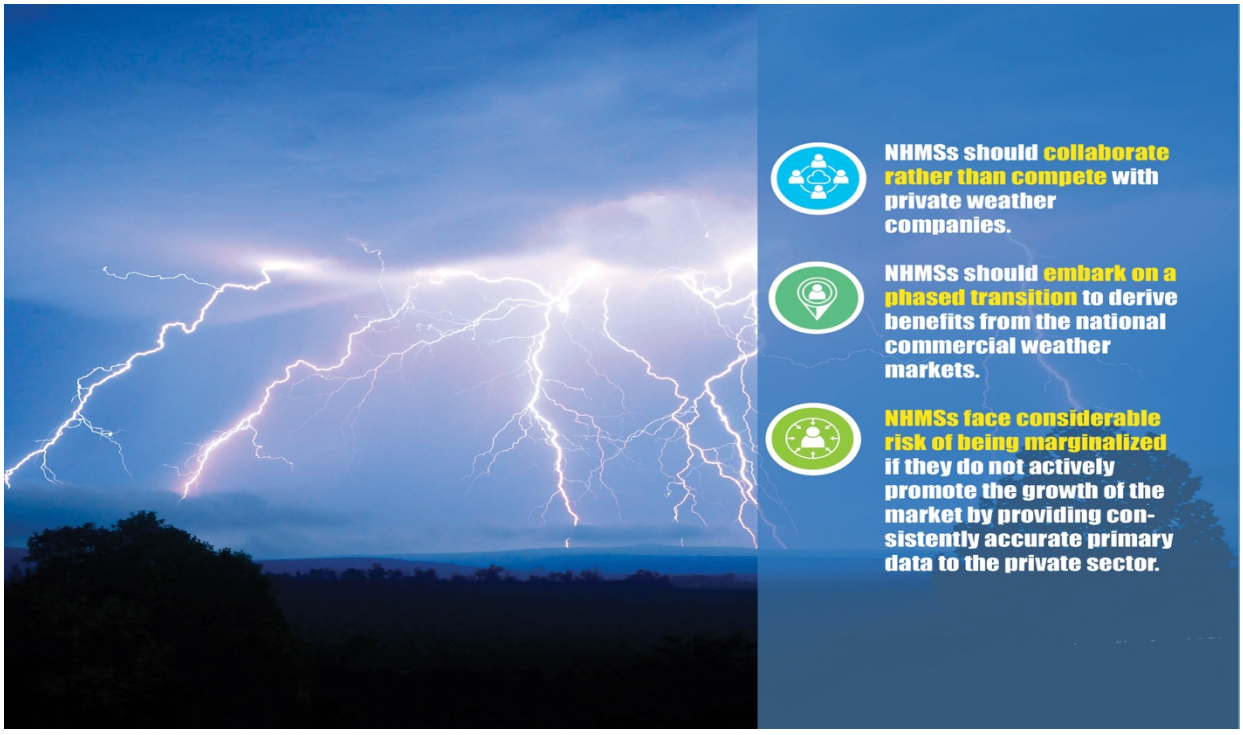
# EXECUTIVE SUMMARY

The availability, diversity, sophistication and use of weather information is increasing rapidly within the public and private sectors globally. International private weather companies are marketing tailored weather information products intensively and have generated considerable demand from private as well as government customers across a wide range of economic sectors, including agriculture, mining, forestry, construction and energy. The demand is also growing as a result of widespread negative impacts of climate change across these sectors. Although business opportunities abound, the commercial viability of new ventures in this intensely competitive market will be strongly dependent on highly specialised skills in product development and marketing, including the design of weather information products tailored to meet the diverse needs of aviation, farming, tourism and other sectors

Thriving commercial weather markets across the world have invariably been underpinned by National Hydrological and Meteorological Services (NHMSs) that provide consistently accurate primary data – about weather phenomena on the synoptic (large scale) and local scales – generated from their extensive observation networks. Such data can significantly improve the quality of weather information products being provided or developed by private companies for public and commercial use because the products are often solely derived from satellite observation data. The improved quality of products as a result of inclusion of primary weather information – particularly those describing local scale weather phenomena – is likely to give a private weather company a significant competitive advantage over other providers of weather information that do not incorporate such local data.

Private weather companies are not, however, dependent on receiving data from NHMSs because products derived from satellite data can be of sufficient quality to generate sales and better than what can be obtained from public agencies. These companies are consequently not beholden to the NHMSs. It is rather the NHMSs – as a result of their limited skillsets in developing weather markets – that face the considerable risk of being marginalised if they do not actively promote the growth of the market by providing consistently accurate primary data to the private sector. Such marginalisation is highly undesirable from a public perspective because a growing, diverse market for commercial weather services serves both public needs and private interests. The availability of improved weather products across all economic sectors can, for example, reduce loss of life and damage to infrastructure during extreme weather events, diversify the economy by creating new business opportunities, and consequently increase tax revenues for governments. Conversely, if reliable and timely weather information is only available to those who can afford to pay for weather information products, a large share of the population in developing countries will be unserved, with detrimental effects for the entire economy.



This continental-scale market assessment investigated how thriving commercial weather markets could be catalysed in the 11 African countries supported by the CIRDA programme, and how their NHMSs could maximise benefit they derive from such markets. Two main conclusions emerged: firstly, that the NHMSs should collaborate rather than compete with private weather companies; and secondly, that the NHMSs should embark on a phased transition to derive benefits from the national commercial weather markets.

Collaboration with the private sector is advisable because the skills, core business objectives, and comparative advantages of private weather companies compared with those of NHMSs are very different. Such companies are innovating rapidly, using state-of-the-art technologies, and generating demand for their products through intensive marketing targeting specific user groups. By contrast, NHMSs focus on providing public goods such as basic weather forecasts to the general public, an accurate national climate record, and early warnings of hazardous weather events; they consequently do not yet have the business skills required for developing and marketing cutting edge products. By providing accurate data and working closely with the private sector to improve the quality of climate and weather information products available in their countries, NHMSs can potentially share, through royalties or fixed fees, the revenues generated from products that incorporate their primary data. Such business deals are – as has already been demonstrated in some countries – likely to generate far greater income streams for the NHMSs than from the simple sale of primary weather data.

This market assessment also found that NHMSs in countries supported by the CIRDA programme were in varying states of readiness for engaging with the private sector. To maximise future shared revenue streams from the private sector, NHMSs will need to undergo major changes in mind-sets and acquire new skills – a cultural shift for agencies unaccustomed to outreach and collaboration with private companies. This transition will take many years – perhaps even a decade – to achieve, especially if laws need to be changed, new partners and working arrangement identified, and new staff hired. An important next step for NHMSs will be to undertake in-depth national market assessments to identify suitable entry points into their respective commercial weather markets. It is recommended that the NHMSs engage with two different types of companies: firstly those specialising in the provision of weather data, applications, or services; and secondly those with no specific sectoral experience, but which focus primarily on business development, sales and marketing.

# GLOSSARY

***Automatic Weather Station (AWS)***

An Automatic Weather Station is defined as a "meteorological observing station at which observations and measurements are made and transmitted automatically". The observations or collected data can be processed locally at the AWS or transmitted elsewhere for processing, for example at the central processor of a network of AWS. AWSs can be designed as an integration of individual instruments (sensors) with interfaces and processing and transmission units; in the U.S.A, such a system is usually called an automated weather observing system (AWOS) or automated surface observing system (ASOS). In addition, an AWS can consist of a single integrated system of sensors and related electronics, which are called All-in-One AWS or AIO AWS.

***CIRDA***

UNDP's Programme on Climate Information for Resilient Development in Africa (CIRDA) connects ideas, people and technology to build resilience to climate change. This multi-country programme supports Climate and weather information and Early-Warning Systems Projects in 11 of Africa's Least Developed Countries in their missions to save lives and improve livelihoods. By building capacity to issue warnings of impending hazardous weather, sharing new technological advances in climate and weather monitoring and forecasting, and facilitating innovative partnerships with the private sector, the programme works to foster regional cooperation, support strong institutions and build resiliency to climate change.

***Climate***

Climate is the average weather condition for a particular location and period of time, described in terms of statistical descriptions of the average and variability of elements such as temperature, precipitation, atmospheric pressure, humidity and winds or through combinations of elements, typical to a location, region or the world. While "weather" reflects short-term (up to 14 days) conditions of the atmosphere, "climate" is the average daily weather for an extended period of time (from 14 days onwards) at a certain location.

***Climate Change***

A non-random change in climate that is measured over several decades or longer. The change may be a result of natural or anthropogenic causes.

***Climate Services***

Climate services refer to the provision of one or more weather and/or climate products or advice in such a way that it assists decision-making by individuals or organisations. The definition includes both climate and weather related products, services and advice.

***Disaster Risk Reduction***

Disaster risk reduction (DRR) is a systematic approach to identifying, assessing and reducing the risks and damage caused by natural hazards such as earthquakes, floods, droughts and cyclones, through an ethic of prevention.

***Early Warning Systems***

Early Warning Systems (EWS), or Multi-Hazard Early Warning Systems (MHEWS), are climate and weather monitoring tools, used to detect, monitor and forecast for *inter alia* floods, droughts, storms, bushfires, tsunami, and other natural hazards. All EWS also include: i) analyses of risks involved; ii) the ability to disseminate timely warnings preferably carrying official or statutory status and serving as the "official" source for the area; and iii) the ability to activate emergency plans to prepare and respond.

***Last Mile***

The Last Mile is a term originating in the telecommunications and technology industries that is used to describe the technologies and processes that connect the end customer to a communications network. The last mile is often stated in terms of the "Last-Mile problem", because the end link between consumers and connectivity has proved to be disproportionately expensive to solve. This assignment particularly discusses the challenges in serving climate services to individuals (not organisations), mainly rural consumers of climate services and smallholder farmers.

***Market Assessment***

A market assessment is a detailed evaluation of the potential of a new product, business idea or investment. Opportunities for these new ventures should be analysed and include market trends, barriers to entry, competition, risks, opportunities and potential pathways.

***Model Output Statistics (MOS)***

Statistical techniques for the generation of point specific values from numerical model outputs. MOS is an objective, site-specific weather forecasting technique which consists of determining a statistical relationship between a quantity (such as temperature) to be predicted and variables forecast by a numerical model at specified forecast time(s).

***National Hydrological and Meteorological Service (NHMS)***

Generally used to indicate that the national meteorological and hydrological functions are in one institute, as is the case in the USA with the NOAA National Weather Service. However, in some African countries – such as Zambia – the Hydrological and Meteorological Services are in two separate departments.

***Private Weather Company***

A private weather company is any privately held company that uses basic hydro-meteorological data and common hydro-meteorological information, usually sourced from public sources, and transforms these into a form and detail useful to specific weather and water resources sensitive users. Private weather companies provide general and tailored climate and weather products (including hydro-meteorological forecasts and value-added products), and services to segments of the population with specialised needs.

***Synoptic Weather Observations***

These are weather observations and measurements made for the purpose of providing information on synoptic weather phenomena. Synoptic observations are made at times and using instruments and techniques that follow to the extent possible the guidelines of the World Meteorological Organisation. The observations are shared around the world using the WMO Global Telecommunications System. Synoptic observations provide information on the general weather in a region, are used as input to numerical models, and are compiled over time to provide information on the regional climate. These observations include both surface and upper air measurements. Synoptic surface weather observations are made at sites selected to be as representative as possible of the weather occurring over the surrounding region. Spacing between surface observing sites varies with the nature of the surrounding terrain, being a few tens of kilometres in mountainous regions and around 100 to 150 kilometres in open plains. Synoptic surface observations are usually reported hourly, every three hours, and/or every six hours, depending on local policies. Upper air observations extending from surface through the troposphere and into the lower stratosphere are made twice daily at stations 200 to 300 km apart, using instruments borne aloft by balloons.

***Tailored Climate and Weather Products***

Tailored weather or climate products (or climate and weather information) refer to those products developed for any segment of the population or economy with specialised needs. Tailored products are distinguishable from freely available, public climate and weather information, which is normally focused on basic forecasting and public safety (for example, early warnings).

***Weather***

Weather is the state of the atmosphere at a given time and place, with respect to variables such as temperature, precipitation, atmospheric pressure, humidity and winds. While "weather" reflects short-term (up to 14 days) conditions of the atmosphere, "climate" is the average daily weather for an extended period of time (from 14 days onwards) at a certain location.

***Climate and Weather Information***

Climate and weather information is synonymous with climate services, for example, the provision of weather and/or climate products or advice to assist decision-making by individuals or organisations. Climate and weather information is derived from (raw) hydro-meteorological data, also known as weather or climate data.

***Weather Market***

A weather market is any market – public and private – for tailored climate and weather products or climate services. A national weather market is the weather market within a country.

# ACRONYM LIST

| | |
|---|---|
| ACARS | Aircraft Communications Addressing and Reporting Systems |
| ACLE | African Centres for Lightning and Electromagnetics |
| ACMAD | African Centre of Meteorological Application for Development |
| AEMET | Spanish Meteorological Agency |
| AFCAC | African Civil Aviation Commission |
| AMCOMET | African Ministerial Conference on Meteorology |
| AMESD | African Monitoring of Environment for Sustainable Development |
| ASECNA | Agency for the Security of Aerial Navigation in Africa and Madagascar |
| AU | African Union |
| AUC | African Union Commission |
| AWS | Automatic Weather Stations |
| CAA | Civil Aviation Authority |
| CAADP | Comprehensive Africa Agricultural Development Programme |
| CAgM | Joint Commission for Agricultural Meteorology |
| CASSOA | Civil Aviation Safety and Security Oversight Agency |
| CBO | Community-Based Organisation |
| CCA | Climate Change Adaptation |
| CCCA | Climate Change Centre Austria |
| CECAF | Committee for the Eastern Central Atlantic Fisheries |
| CEMAC | The Economic and Monetary Community of Central Africa |
| CGIAR | Consortium of International Agricultural Research Centres |
| CHAI | Climate Change Adaptation Innovation |
| CICERO | Centre for International Climate and Environmental Research – Oslo |
| CILSS | Inter-State Committee against Drought in the Sahel |
| CIRDA | UNDP Programme on Climate Information for Resilient Development in Africa |
| COMHAFAT | Ministerial Conference on Fisheries Cooperation among African States Bordering the Atlantic Ocean |
| CPC | Climatic Prediction Centre |
| CRADA | Cooperative Research and Development Agreements |
| CSP | Climate Services Partnership |
| CSC | Climate Service Centre |
| CWOP | Citizen Weather Observer Programme |
| DMC | Drought Monitoring Centre |
| DOM | Department of Meteorology |
| DRM | Disaster Risk Management |
| EARS | Environmental Analysis and Remote Sensing |
| ECOWAS | Economic Community of West African States |
| EDF | European Development Fund |
| EMC | Environmental Modelling Centre |
| ENACTS | Enhancing National Climate Time Series |
| EO | Earth Observation |
| ESAF | Eastern and Southern African |
| EUMETSAT | European Organisation for the Exploitation of Meteorological Satellites |
| EWBMS | Energy and Water Balance Monitoring System |

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|---|---|
| FESA | Food Early Solutions for Africa |
| GFCS | Global Framework for Climate Services |
| GMES | Global Monitoring of Environment and Safety |
| HARITA | Horn of Africa Risk Transfer for Adaptation |
| HNI | Human Networks International |
| ICAO | International Civil Aviation Organisation |
| ICPAC | IGAD Climate Prediction and Applications Centre |
| ICT | Information and Communication Technology |
| IFA | Insurance-For-Assets |
| IFRC | International Federation of Red Cross and Red Crescent Societies |
| IOC | Indian Ocean Commission |
| JCOMM | Joint Technical Commission for Oceanography and Marine Meteorology |
| JPI | Joint Programming Initiative |
| KMS | Kenya Meteorological Service |
| KNMI | Royal Dutch Meteorological Institute |
| LVFO | Lake Victoria Fisheries Organisation |
| MESA | Monitoring of Environment and Security in Africa |
| METAR | Meteorological Aviation Routine reports |
| MoU | Memorandum of Understanding |
| NCEP | National Centre for Environmental Prediction's |
| NEPAD | New Partnership for Africa's Development |
| NFCS | National Framework for Climate Services |
| NGO | Non-Governmental Organisation |
| NMA | National Meteorological Agency |
| NHMS | National Meteorological and Hydrological Services |
| NOAA | National Oceanic and Atmospheric Administration |
| OECD | Organisation for Economic Co-operation and Development |
| PAF | Partnership for African Fisheries |
| PATWAS | Pilots Automatic Telephone Weather Answering Service |
| PFI | Policy Framework for Investment |
| PIDA | Programme for Infrastructure Development in Africa |
| PIREPs | Pilot Reports |
| PPP | Public-Private Partnership |
| QMS | Quality Management System |
| RCC | Regional Climate Centre |
| SA | Surface Area |
| SADC | Southern African Development Community |
| SARIS | Southern Africa Regional Integration Strategy |
| SARPs | Standards and Recommended Practices |
| SBIR | Small Business Innovation Research Programme |
| SIAC | Statistics in Applied Climatology |
| SMS | Short Message Service |
| SSC | Statistical Services Centre |
| SWFDP | Severe Weather Forecasting Demonstration Project |
| TAF | Terminal Airport Forecast |
| TAHMO | Trans-African Hydro-Meteorological Observatory |
| TCI | Tourist Climate Index |

| | |
|---|---|
| TF | Terminal Forecast |
| UNECA | United Nations Economic Commission for Africa |
| UNWFP | United Nations World Food Programme |
| USSD | Unstructured Supplementary Services Data |
| VCP | Voluntary Cooperation Programme |
| WACAF | Western and Central African |
| WAEMU | West African Economic and Monetary Union |
| WASCAL | West African Science Service Centre on Climate Change and Adapted Land Use |
| WIBI | Weather Index-Based Insurance |
| WMO | World Meteorological Organisation |
| WTO | World Trade Organisation |

# 1. INTRODUCTION

Africa is extremely vulnerable to climate change for two main reasons: it is the hottest continent on earth, and dry lands/deserts make up 60% of its land surface. Several parts of the continent, such as the drought-prone Sahel, are predicted to undergo extreme shifts in climate with marked increases in the variability of rainfall as well as extreme warming. The negative effects of such changes – including the reduction in land available for subsistence agriculture and pastoralism – will be greatly exacerbated by the generally poor state of economic development and low adaptive capacity of African countries.

Subsistence farming dominates Africa, more so than on any other continent. Currently, there are ~33 million farms smaller than 2 hectares, which comprise ~80% of all the continent's farms. Farming also contributes considerably to the economic development and prosperity of the continent, since the agriculture sector employs ~65% of Africa's labour force and accounts for ~32% of its gross domestic product. Most of the agriculture in Africa is small-scale, weakly capitalised, subsistence-oriented and occurs on dry lands. This means that the continent is exceptionally sensitive to climate changes and in particular climate variability[1]. These changes in climate threaten development goals and compromise strategies aimed at poverty alleviation. The ability of decision-makers to understand and communicate the likely impacts of climate change is important for adapting development plans to new climate realities. However, limited access to reliable climate and weather information and limited capacity to disseminate this information are considerable obstacles. This often prevents governments and populations from developing the correct tools to address the impact of climate change.

National Hydrological and Meteorological Services (NHMSs) have the potential to make major contributions to the safety, security and economic well-being of the population by observing, forecasting and providing warnings of climate and weather threats. This was highlighted in a recent report[2] from multilateral agencies that underscores the urgency to strengthen NHMSs – particularly those in developing countries – and provides cost-benefit estimates of the return that the NHMSs have the potential to achieve. For example, studies show that economic returns on improved NHMS services result in cost-benefit ratios of 1:4 in Europe to 1:10 in Central Asia. Such quantification of returns on investment help governments to fully appreciated the value of the NHMS to society and should incentivise them to increase their investments in NHMSs, particularly given current and predicted climate change impacts.

Despite the potential contribution of NHMSs to sectors and societies around the world, their true value is rarely quantified in developing nations. In particular, the role that these agencies play in the management of meteorological and hydrological hazards is undervalued. Similarly, there is limited awareness of the economic benefits associated with integrating accurate and timely climate and weather information into decision-making processes in climate-vulnerable sectors – such as agriculture – to increase productivity and avoid losses[3]. This information should be provided through climate services[4] to individuals and organisations to support adequate response to gradual and extreme changes in climate.

To address the challenges described above, the Programme on Climate and Information for Resilient Development in Africa (CIRDA) is supporting national climate services within 11 African countries[5]. The support largely comprises capacity building for collecting, analysing and disseminating climate and weather information as a tool to save lives and develop long-term planning for, and adaptation to, climate change.

CIRDA is expected to benefit the NHMS of the 11 countries in the following ways:

- assist with meeting the requirements to generate, process and disseminate high quality, timely climate and weather data that are comprehensive, reliable and accessible to end users;

[1] NEPAD. 2013. Agriculture in Africa: transformation and outlook.
[2] WMO. 2015. Valuing Climate and weather: Economic Assessment of Meteorological and Hydrological Services. World Meteorological Organisation.
[3] WMO. 2013. A workshop to assist in: sustaining national meteorological services – strengthening WMO regional and global centres, a final report. Washington DC, U.S.A., 18-20 June 2013.
[4] The provision of one or more weather and/or climate products or advice in such a way that it assists decision-making by individuals or organisations.
[5] These countries include: Benin, Burkina Faso, Ethiopia, Liberia, Malawi, Sao Tome and Principe, Sierra Leone, Tanzania, The Gambia, Uganda and Zambia.

- enable vulnerable communities, farmers and policymakers in Africa to access and use climate data to make informed decisions on how to cope with a changing climate;
- assist with bringing innovative, reliable, low-cost and easily maintained technologies with national coverage and cellular links to NHMSs; and
- strengthen local responses to climate change to benefit human wellbeing, food production and national and regional security

This market assessment is an important step towards strengthening the supply of, and demand for, climate services. The demand side, which comprises a complex and diverse market, is restricted to the private sector for the purposes of this assessment. It is important to note however, that this excludes other market participants such as public sector institutions and government departments, which may be significant consumers of climate services. Analysis of the supply side focusses primarily on the NHMS providing climate services – either directly or indirectly – to end users.

The objective of the assessment is to provide the CIRDA programme and country project offices with information on: i) market-oriented opportunities for the development and provision of tailored climate and weather products and services – "climate services"; ii) the threats and opportunities for investment in climate services presented by the private weather sector; iii) case studies of successful market-oriented products and services in developing and developed countries; and iv) potential pathways and modalities for developing the capacity and response of NHMSs to the private sector. The market assessment will include the presentation of business models that are suitable for developing revenue streams for the NHMSs.

# 2. STUDY APPROACH

A typical market assessment methodology employs a top-down approach. In the context of this assessment, such an approach would have included exploring the growth and development of relevant climate services and their providers (public and private) in similar but more developed markets, and drawing conclusions from these experiences for African countries supported by the CIRDA programme. However, engagement with stakeholders in the African countries supported by the CIRDA programme revealed that such an approach was not suitable for this particular assessment because: i) the readiness of NHMSs to engage the private sector in African countries supported by the CIRDA programme is variable; ii) the economies of the African countries supported by the CIRDA programme are not homogenous; iii) comparisons to more developed – mostly European – economies are not always appropriate; and iv) privately-owned weather companies in developing countries – e.g. India – have only developed a strong presence over the last 10-20 years. Furthermore, many of the privately-owned weather companies are not willing to disclose details on product revenues or other pertinent market-related information.

Given the above information, it was decided to employ a bottom-up – rather than top-down – approach. The market assessment was undertaken between July 2015 and January 2016 and was informed by a desktop review and interviews with stakeholders in the NHMSs within the African countries supported by the CIRDA programme, multilateral institutions, NGOs and the private sector. The assessment sought to: i) broadly assess the readiness of the NHMSs in the African countries supported by the CIRDA programme for private sector engagement; ii) explore the role and potential participation of private weather companies in the climate services market as both competitors and partners of the NHMSs; iii) examine potential partnerships between the NHMSs and leading sectors, including pathways for developing market opportunities; iv) provide illustrative case studies that show best practices and other working models; and v) describe barriers and solutions to bridge the Last Mile communication challenge.

Through the market assessment, a number of important interactions and relationships within national weather markets were studied. A conceptual framework of these relationships is presented in Figure 2.1 below, with each line arrow depicting a particular relationship. Explanations of these relationships are presented below Figure 2.1.

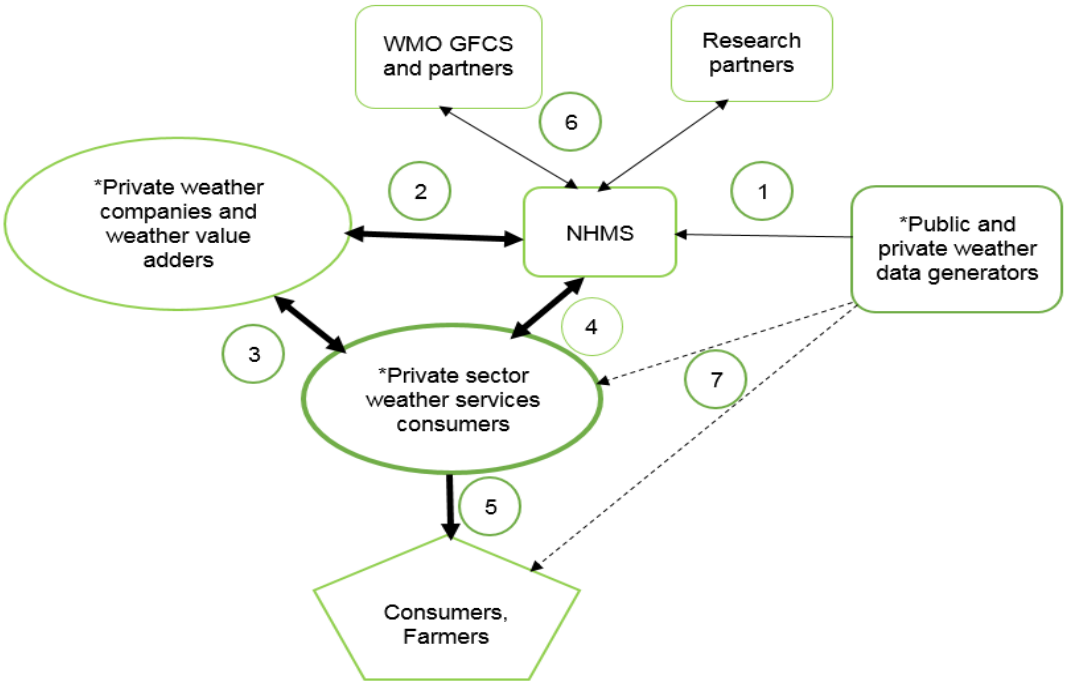


**Figure 2.1.** A conceptual model depicting the relationships between the different agents in the weather sector: either as data generators, partners, private or public weather organisations, and intermediaries or

consumers of tailored weather products. The strength of each relationship is represented by the thickness of the arrow linking the two agents.

1. Arrow 1 illustrates a moderately strong relationship between NHMSs and weather data generators. This includes organisations such as the National Oceanic and Atmospheric Administration (NOAA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT).
2. Arrow 2 illustrates a strong relationship between the NHMS and private sector climate and weather information providers. This includes private weather companies or "value-adders" that act as intermediaries between the NHMS and private sector data users.
3. Arrow 3 illustrates a strong relationship between private sector climate and weather information providers and companies using data generated by climate services — climate service consumers.
4. Arrow 4 illustrates a strong relationship between climate services consumers in the private sector and the NHMS.
5. Arrow 5 illustrates a strong relationship between climate services consumers in the private sector and the end users of climate and weather information – particularly local communities and farmers. This link is hereafter referred to as "the Last Mile".
6. Arrow 6 explains the institutional framework that guides the NHMS, highlighting a moderately strong relationship between the NHMS and research institutions.
7. Arrow 7 illustrates a weak relationship between public and private weather data generators and private sector climate services consumers. In this case, the NHMS is circumvented and the weather services consumers obtain data for use directly from the data generators.

# 3. INSTITUTIONAL FRAMEWORK

Products generated from climate services include high-quality data from national and international databases on weather variables – including temperature, rainfall, wind, soil moisture and ocean conditions. Climate services also contribute to the production of maps, risk and vulnerability analyses and long-term scenarios. Generating this information requires engagement with stakeholders and an effective communication mechanism that is in line with user needs – for example, through applications, the internet or Short Message Service (SMS). If required by the user, these data and information products are packaged along with non-meteorological data. Such non-meteorological data could include information on agricultural production, health trends, population distributions in high-risk areas, road and infrastructure maps and other socio-economic variables.

## 3.1 The roles of the Global Framework for Climate Services and the World Meteorological Organisation

Although the size of the continent is considerable, Africa has the least developed climate and weather land-based observation network of all the continents. Furthermore, the observation network is only about one eighth as dense as the minimum density recommended by the World Meteorological Organisation (WMO)[6]. The WMO is a specialised agency of the United Nations and contributes to policy formulation on climate and weather at national and international levels. Particularly, the WMO promotes the following:

- worldwide cooperation in the establishment of station networks for meteorological, climatological, hydrological and geophysical observations;
- the establishment and maintenance of systems for exchanging, processing and standardising meteorological and related data to promote uniform publication of observations and statistics;
- collaboration between NHMSs;
- the application of meteorological information in aviation, shipping, water problems, agriculture and other human activities;
- research on and training in meteorology and related fields, assistance with technology transfer and coordination of the international aspects of this research and training; and
- the free and unrestricted exchange of data and information as well as products and services in real- or near real-time on matters relating to safety and security of society, economic welfare and the protection of the environment.

To address global limitations in weather observation networks, the WMO established the Global Framework for Climate Services (GFCS). This framework is an international partnership between WMO members, governments and organisations. The mandate of the GFCS is to produce and use climate and weather information to build on scientific research, with the main objective of strengthening and expanding the provision of climate services. The vision of the framework is to develop societies that are able to manage risks and opportunities related to climate variability and change in an appropriate way, with a focus on those societies most vulnerable to climate-related hazards. The GCFS consequently focusses mainly on developing countries that have limited or non-existent climate services.

To achieve the vision described in the paragraph above, accurate climate and weather information needs to be produced and incorporated into planning, policy and practice. In particular, partners of the GFCS have identified five priority planning themes: i) agriculture and food security; ii) disaster risk reduction; iii) energy; iv) health; and v) water. The GFCS also enhances partnerships between providers and users of climate services and promotes regional and sub-regional cooperation to improve planning.

The Implementation Plan (IP) of the GFCS identifies projects to address the priority areas described above. Undertaking these projects demonstrates the value of the GFCS to providers, users and donors, and

[6] http://www.wmo.int/amcomet/en/pages/integrated-african-strategy-meteorology-weather-and-climate-services. Accessed on 7 September 2015.

promotes their sustained commitment while delivering benefits to society[7]. Of particular relevance are the pilot projects that the GFCS has implemented within some of the Countries supported by the CIRDA programme. These pilot projects should serve as best practices and lessons learned for the development of climate products and services in other African countries supported by the CIRDA programme and for the upscaling of projects within each country. The relevant pilot projects are detailed below.

*Across Africa: Climate Services Adaptation and Disaster Risk Reduction in Africa (2011–2016)*

This project has two main objectives, namely: i) building capacity for improved climate services; and ii) developing weather- and climate-related services for agriculture. The project aims to upscale existing initiatives that have been successful at national level to larger geographic areas. Examples of these initiatives include: i) the Severe Weather Forecasting Demonstration Project – in Least Developed Countries and Small Island Developing States; and ii) the METAGRI Operational Project – functioning in the African countries of Benin, Burkina Faso and the Gambia.

*Ethiopia, Malawi and Zambia: R4 Rural Resilience Initiative (2011–2017)* [8]

The R4 initiative unites public and private sector actors – including the UN World Food Programme (UNWFP), Oxfam, Swiss Re, local government and the NHMSs – in a strategic large-scale initiative. This initiative builds on the Horn of Africa Risk Transfer for Adaptation (HARITA) project developed by Oxfam to allow poor farmers to strengthen their food and income security. Through the initiative, four risk management strategies are being implemented, namely: i) improved resource management by means of asset creation (risk reduction); ii) insurance (risk transfer); iii) livelihoods diversification and microcredit (prudent risk taking); and iv) savings (risk reserves). R4 is innovative in that it enables the poorest farmers to pay for crop insurance with their own labour as described below.

Under the R4 framework and through continuous interaction with the community and local experts, a weather index – such as accumulated rainfall – is created and used to target particular farmer risks. Farmers can access this Weather Index-Based Insurance (WIBI) by paying with their labour using Insurance-for-Assets (IFA) schemes. When a drought occurs, compensation for weather-related losses prevents farmers from having to sell productive assets, which stimulates faster post-drought economic recovery. If the right systems are in place, WIBI can contribute substantially to climate risk management among targeted communities. However, few successful case studies of WIBI have been recorded in countries (see annex C6).

*Malawi and Tanzania: Climate Services Adaptation Programme in Africa – Building Resilience in Disaster Risk Management, Food Security and Health (2013–2016)*[9]

This flagship programme was the first multi-agency initiative to be implemented under the GFCS. The main objective of this programme is to develop user-driven climate services for food security, health and disaster risk reduction in Malawi and Tanzania. By achieving this objective, the programme will contribute towards increasing the resilience of people most vulnerable to the impacts of climate and weather-related hazards such as droughts and floods, as well as associated health risks – including malnutrition, cholera and malaria. In particular, the project will strengthen the capacity of stakeholders to develop and use climate services by combining science with traditional knowledge. This programme represents a unique partnership between a variety of stakeholders including *inter alia:* i) the WMO; ii) the Consortium of International Agricultural Research Centres (CGIAR) Research Programme on Climate Change; iii) the Centre for International Climate and Environmental Research – Oslo (CICERO); and iv) the International Federation of Red Cross and Red Crescent Societies (IFRC) through the Tanzanian and Malawian Red Cross, and the UNWFP.

[7] WMO. 2012. Implementation plan of the Global Framework for Climate Services (GFCS).
[8] For more information about this project, please refer to Mr Daniel Longhurst of the World Food Programme. Contact details to be found in Annex 2.
[9] For more information about this programme, please refer to Mr Andrew Kruczkiewicz from the Red Cross and IRI. Contact details to be found in Annex 2.

*Climate Services Partnership (CSP)*

Another international initiative within the GFCS framework is the Climate Services Partnership (CSP). This partnership is a global platform for knowledge sharing and collaboration to promote climate change resilience and advance climate service capabilities worldwide. It is an informal, interdisciplinary network of climate and weather information users, providers, donors and researchers. The CSP focuses on the following three aspects:

- forging connections;
- sharing knowledge and lessons learned; and
- creating new knowledge.

Project activities of the CSP inform and support the evolution as well as the implementation of the GFCS and include the following projects:

*Ethiopia: Enhancing National Climate Time Series (ENACTS)*[10]

ENACTS supports decision-makers in climate-sensitive sectors by filling spatial and temporal gaps in existing climate observations. In addition, ENACTS provides an array of tailored products – for example, sector-specific map sites – available to users thorough the internet. This project mainly supports the agriculture, water and public health sectors, and was funded by Google from January 2008 to December 2011. ENACTS in Ethiopia can be used as a template for improving climate services across Africa because: i) raw satellite data for the past 30 years has been obtained and processed for the entire continent, so ENACTS has the potential to be transferred to other countries; ii) carrying out similar projects in other African countries will now be faster, less expensive and more efficient as lessons have been learned; and iii) methodologies and computer codes developed for generating the climate time series can easily be adopted for other countries.

Currently, the CSP is collecting data for its climate services mapping initiative. The project – which will catalogue climate services around the world – is being conducted in tandem with a European-focused effort led by Germany's Climate Service Centre (CSC) and the Climate Change Centre Austria (CCCA), in support of the European Joint Programming Initiative (JPI) Climate.

Other projects in the region implemented by GFCS partners include the Health Risk Management in a Changing Climate project in *inter alia* Tanzania. This project is improving the use of early warning information by implementing community-level health interventions in selected communities throughout the Tanga region of Tanzania. In particular, the project is designed to decrease the risk of malaria and diarrheal disease for ~90,000 beneficiaries in the region. It will also improve the capacity of the Tanga branch of the Tanzanian Red Cross to understand and communicate the connection between climate change and health[11].

## 3.2 Regional frameworks and cooperation

In the past three decades, several regional institutions were established to promote coordination and sharing of climate and weather information between countries in Africa.

In 1987, the Conference of Ministers of the United Nations Economic Commission for Africa (UNECA) and the WMO established the African Centre of Meteorological Application for Development (ACMAD) as a first regional centre for meteorology in Africa. ACMAD consists of 53 Member States, representing the 53 countries of the continent**.** Its mandate is to provide climate and weather information to support the sustainable development of the agriculture, water resources, health, public safety and renewable energy

[10] For more information about this project, please refer to Mr Tufa Dinku from the IRI at Columbia University. Contact details to be found in Annex 2.
[11] For more information about this programme, please refer to Mr Andrew Kruczkiewicz from the Red Cross and IRI. Contact details to be found in Annex 2.

sectors in Africa. This mandate is being achieved through: i) capacity building of the 53 NHMSs of its member states; ii) weather prediction; iii) climate monitoring; iv) transfer of technology (telecommunications, computing and rural communication); and v) research.

ACMAD has distributed climate and weather information at different time scales. In 2008, a special desk was established to provide meteorological information for disaster mitigation and decision-making regarding response-oriented activities. Since late 2011, the services that this initiative provided were upscaled throughout Africa. In particular, the service provides flood-risk forecasting, from weekly forecasting to nowcasting — detailed descriptions of current weather along with forecasts obtained by extrapolation for a period of 0 to 6 hours ahead — for mitigation and disaster risk management action. The CIRDA programme is collaborating closely with ACMAD through a member of the CIRDA team[12] who is undertaking work in conjunction with ACMAD.

In 2010, the African Ministerial Conference on Meteorology (AMCOMET) was established as a mechanism to generate and implement climate services to support socio-economic development in Africa. This objective is promoted by establishing political leadership, guidance, policy direction, and advocacy. In 2012, the ministers of the member countries[13] adopted the Integrated Strategy on Meteorology (2013–2017). The main purpose of the strategy is to provide a framework for coordination and effective mainstreaming of climate services into sub-regional and national development policies and plans in Africa. In particular, the strategy focuses on the following five inter-related strategic pillars:

- increase political support and recognition of NHMSs and related WMO regional climate centres;
- enhance the production and delivery of climate services for sustainable development;
- improve access to meteorological services, in particular for the marine and aviation sectors;
- support the provision of climate services for climate change adaptation and mitigation; and
- strengthen partnerships with relevant institutions and funding mechanisms.

Furthermore, the strategy will provide guidance for the implementation of a structured GFCS in Africa, based on *inter alia* WMO's Implementation Plan of the GFCS. During the third AMCOMET meeting in February 2015, a proposal was made to establish a regional climate centre in Central Africa.

*East Africa*

The Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Centre (ICPAC) – formally the Drought Monitoring Centre (DMC) – comprises 11 countries in East Africa, including several countries supported by the CIRDA programme (namely Ethiopia, Tanzania and Uganda). The mission of the centre is to provide timely early warning information on climate-related hazards and support the sector-specific application of this information. This will enhance the ability of participating countries to cope with the variety of risks associated with extreme climate variability. The ICPAC is of considerable relevance to the countries supported by the CIRDA programme as it *inter alia*: i) acquires climate and remote sensing data; ii) processes the data to develop basic statistics for baseline risk scenarios; iii) maps hazards and climate risks; iv) provides a network with WMO, the NHMS and other regional centres to exchange information; and v) increases capacity to generate and apply climate information and products[14]. Current products by ICPAC include the following: i) ten-day, monthly and seasonal climate/weather bulletins; ii) climate watch/El Niño updates; and iii) annual climate summaries.

*West Africa*

In 1974, AGRHYMET[15] was established as a specialised branch of the Inter-State Committee against Drought in the Sahel (CILSS). AGRHYMET is the technical arm of the Economic Community of West African States (ECOWAS) and includes 13 countries, of which Benin, Burkina Faso and the Gambia are countries supported

[12] This CIRDA member is Dr Ulrich Diasso who is based in Burkina Faso.
[13] All countries in Africa are a member.
[14] http://www.icpac.net/background/background.html#background. Accessed on 7 September 2015.
[15] This is a compiled acronym of the terms agro-meteorology, hydrology, and meteorology.

by the CIRDA programme. In addition, AGRHYMET is the WMO West-African Regional Climate Centre (RCC). The role of the RCC is to become an institute of excellence to create regional climate products – including long-range forecasts – that support regional and national climate activities. This will strengthen the capacity of WMO members in a given region to provide national users with tried-and-tested climate services. The main funding source of the RCC is the contribution by its member states, with additional funding by national and international development partners. AGRHYMET is also a WMO-certified training centre that provides information and training to NHMS staff and counterparts in agro-meteorology, hydrology and meteorology. Moreover, AGRHYMET: i) collects, processes and disseminates data and information on food security, water resource management and climate change impacts; ii) undertakes monitoring; iii) acts as a regional data bank for data and documents; and iv) promotes the exchange of technologies between its member states.

In addition to AGRHYMET, the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL)[16] assists 10 countries in West Africa – including the countries of Benin, Burkina Faso and the Gambia – to develop an effective approach to adapt to climate change and climate variability. WASCAL is a large-scale, research-focused Climate Service Centre whose objectives are to strengthen the research infrastructure and technical capacity of the 10 targeted countries to adapt to climate change in West Africa. Projects under WASCAL are implemented in collaboration with West African countries and German partners. These projects offer various study programmes and information on the onset of the rainy season, climate change scenarios, water availability scenarios and agricultural production forecasting. Examples of partners of WASCAL include universities, NHMSs and regional institutions such as ACMAD, the ECOWAS and AGRHYMET.

In 2007, the Afrimet Conference of Directors of West African National Meteorological Services was established in collaboration with WMO and the Spanish Meteorological Agency (AEMET). The CIRDA member countries include Benin, Burkina Faso, the Gambia, Liberia and Sierra Leone. The main objective of the conference is to: i) support collaboration between the NHMSs of the member countries; ii) facilitate the detection of problems; and iii) promote the adoption of relevant decisions. To achieve this objective, the cooperation model among the West African NHMSs looks for synergies that result from implementing a regional approach. The conference is organised into a number of projects. Each project has a WMO technical focal point and an AEMET project coordinator who manages the project. These individuals maintain close contact with the local focal points in each of the project's participating countries. The projects are separated into different actions and the conference is expected to develop and implement both annual plans and long-term action plans. In addition, conclusions of the conference of directors have to be submitted to the Ministries in charge of meteorology in each participating country as well as CILSS, ECOWAS and the WMO. These resolutions are submitted to promote cooperation – at national and international levels – in meteorology and hydrology in the North and West Africa region. The conference is financed by the AEMET trustee fund retained in the WMO, which is a seed fund designed for improving the political and financial support for the NHMSs on a national level.

To further assist with improving the communication of climate and weather information in Africa, Regional Climate Outlook Forums have been established to regularly provide seasonal climate outlooks. The data generated by these regional outlooks are downscaled to national and local levels into National Frameworks for Climate Services (NFCS). The regional outlooks have therefore become an important management tool for agriculture, water, disaster risk reduction and health sectors. CIRDA is already aware of and using the information from these Regional Climate Outlook Forums through a member of the CIRDA team who is disseminating the Forum's bulletins to the rest of the team[17].

## 3.3 National Frameworks for Climate Services (NFCS)

The NFCS is to be developed by each CIRDA country to create an enabling environment to produce and disseminate climate and weather information. Currently, producing and disseminating this weather information is challenging, as meteorological services in Africa fall under the responsibility of several different ministries – including transport, agriculture and environment – that often operate in isolation. To

[16] http://www.wascal.org/about-wascal/partners/. Accessed 7 September 2015.
[17] Mark Tadross: mark.tadross@undp.org.

overcome this challenge, AMCOMET has proposed an Integrated African Strategy for Meteorology that will contribute to: i) integrating climate services across the main economic and climate sensitive sectors; ii) enhancing cooperation between African institutions; and iii) strengthening the capacity and relevance of the NHMSs. Additionally, the integrated strategy will become an essential component for the overall national and regional economic development frameworks in Africa thereby increasing the efficiency of addressing poverty reduction, climate change adaptation and disaster risk reduction[18].

[18] Ms Tumusiime Rhoda Peace, AU Commissioner for Rural Economy and Agriculture.

# 4. PUBLIC AND PRIVATE WEATHER DATA PROVIDERS

## 4.1 Background and context

In Africa, the NHMSs obtain climate and weather information from two main sources: weather stations and weather satellites. On-the-ground weather stations are usually owned and run by the NHMS and record a range of physical measurements of the environment. These weather stations produce accurate, fine-scale data that are useful for informing and calibrating weather prediction models. In addition, data has been collected from weather stations over longer time periods than those from satellites. Consequently, these data constitute the climate record for a country and as such are valuable for measuring long-term climate change and calibrating long-term climate forecasts. Alternatively, the majority of data generated by weather satellites are used to provide nowcasting[19] information on rain, lightning, temperature and wind. These data, usually in the form of satellite images, are freely available to NHMSs on online platforms such as SAT24[20]. Data generated from satellite observations are important for: i) numerical weather prediction models[21]; and ii) assisting with detecting potentially hazardous weather developments – such as heavy storms and lightning – using nowcasting and short-term forecasting. The capacity of weather satellites to collect long-term measurements has become increasingly important to support studies on climate change. As most African countries do not have their own weather satellites, they largely rely on the data provided by *inter alia* Europe and the USA for weather forecasting information. To fill this gap in Africa's weather forecasting information, organisations such as the National Oceanic and Atmospheric Administration (NOAA) and EUMETSAT – in compliance with the WMO framework – have developed programmes to assist the local NHMSs in providing more accurate and timely information on climate and weather. NOAA and EUMETSAT have therefore become important global networks in providing climate and weather information in Africa. A more detailed explanation of their work in Africa is described below.

## 4.2 Weather satellites

### *4.2.1 National Oceanic and Atmospheric Administration (NOAA)*

NOAA is a government agency in the USA that provides a variety of climate and weather products and services, including *inter alia*: i) daily weather forecasts; ii) severe storm warnings; iii) climate monitoring for various sectors – such as aviation, fisheries and agriculture; iv) environmental data; and v) climate models[22]. This information can be freely accessed by all interested individuals as well as representatives of research institutes, companies, and NGOs[23].

The NOAA data centres and portals that are of use for the African NHMSs are described below.

- The National Centre for Environmental Information: the Environmental Modelling Centre (EMC) develops and improves numerical weather, climate, hydrological and ocean forecasts.
- The Climatic Prediction Centre (CPC) – African desk[24] was established in 1994 as part of the US contributions to the WMO Voluntary Cooperation Programme (VCP). The objective of the CPC is to help build the capacity of African meteorological institutions to predict, monitor, and assess climate. In 2006,

[19] Nowcasting is the detailed description of the current weather along with forecasts obtained by extrapolation for a period of 0 to 6 hours ahead (WMO).
[20] http://en.sat24.com/en/af. Accessed on 8 September 2015.
[21] These models can analyse and predict a variety of weather phenomena through simulations an atmospheric motion in space and time.
[22] http://www.noaa.gov/about-noaa.html. Accessed on 27 August 2015.
[23] http://techpartnerships.noaa.gov/WorkingwithNOAA/NOAADataCenters.aspx. Accessed on 27 August 2015.
[24] http://www.cpc.ncep.noaa.gov/products/african_desk/cpc_intl/menus/intro.shtml#Introduction. Accessed on 7 September 2015.

the African Desk was expanded to include weather[25] to support the WMO Severe Weather Forecasting Demonstration Project (SWFDP) for the continent. In addition, the African Desk provides access to the National Centre for Environmental Prediction's (NCEP) climate data and products, as well as in-house training for staff of NHMSs in Africa.

NOAA seeks active collaboration with the private sector through the following mechanisms[26]:

- The Small Business Innovation Research programme (SBIR) provides funding for the start-up and early development stages of weather information businesses. In particular, SBIR seeks to develop innovative climate and weather products with excellent commercial potential. To address NOAA's science mission needs, the programme posts an annual public solicitation for private sector partners to develop innovative technological solutions. In addition, funding from the SBIR encourages the commercialisation of NHMSs' technology, products and services – particularly for the potential contribution thereof to the national economy.
- Cooperative Research and Development Agreements (CRADA) are written agreements between a private company and NOAA that promote collaboration on climate research projects. CRADAs facilitate direct public/private collaboration between NOAA scientists and a private company using NOAA's facilities. These agreements can last for up to five years.
- Special Studies Agreements allow private sector companies to request special studies on climate and weather through a NOAA laboratory.

### *4.2.2 The European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)*

EUMETSAT is an intergovernmental organisation that provides operational satellite data, services and products to the NHMSs of its member states in Europe, as well as other users across the world. The organisation operates a system of meteorological satellites that continuously observe and collect data on the atmosphere, oceans and land surface. These data are made freely accessible through an online portal and data centre[27]. In addition, EUMETSAT uses algorithms to generate a range of products and services from the observations made by satellites. For example, it delivers data streams in real time to users in Europe, Africa and the Americas.

EUMETSAT's primary dissemination system for the delivery of near real-time satellite data and products is called EUMETCast. It is also used to distribute third-party meteorological and environmental products from EUMETSAT's Member States and international partners. These include *inter alia*: i) *in situ* observational data; ii) numerical weather forecasts; and iii) global and regional marine meteorological and ocean service products. This delivery mechanism allows users to receive many data streams via one low-cost reception station. EUMETCast currently delivers data streams to thousands of users through a Very Small Aperture Terminal[28] in a secure manner, with flexibility to handle several formats and scalability to accommodate additional data.

[25] Weather is defined here as conditions of the atmosphere over a short period of time, up to a few weeks.
[26] http://techpartnerships.noaa.gov/WorkingwithNOAA.aspx. Accessed on 8 September 2015.
[27] http://www.eumetsat.int/website/home/AboutUs/WhatWeDo/DistributingData/index.html Accessed on 28 August 2015.
[28] This is a two-way satellite communication system via the internet or other networks.

## *EUMETSAT in Africa*

Accurate weather forecasts and severe weather warnings are important in assisting communities in Africa to reduce the negative effects of climate change. Consequently – as part of its strategic plan for the period 2012 to 2015 – the WMO encouraged its member states to improve the service delivery of the NHMSs in Least Developed Countries. EUMETSAT aligns with the WMO objectives in Africa in that its activities are implemented to *inter alia*: i) facilitate access of the NHMSs in Africa to EUMETSAT's data, products and services through training; and ii) make optimal use of available and planned satellite services to assist countries and regions with meeting their respective needs in terms of early warnings, water and agricultural management and mitigation against the effects of natural hazards.

In Africa, EUMETSAT has four training institutions – one each in Morocco, South Africa, Nigeria and Kenya. For one week every year, EUMETSAT provides training at these institutions on new technologies that assist with accessing data. Through improved access to EUMETSAT's data, African NHMSs can: i) provide accurate weather forecasts; ii) monitor extreme weather events; and iii) improve the response of authorities to disasters. Over the last 20 years – in collaboration with a variety of institutions[29] – EUMETSAT has implemented a number of projects. These projects were developed to support EUMETSAT's strategic objectives in Africa, which contributed to the framework of the WMO and Joint EU-Africa strategies.

The Preparation for Use of Meteosat Second Generation in Africa (PUMA) project (2001–2006) provided African NHMSs with access to state-of-the-art Meteosat Second Generation (MSG) satellite data, products and technology for weather forecasting. A pan-African network of 53 countries was created and five regional centres were established and equipped with the infrastructure, training and support required for receiving the latest space-based meteorological and environmental data, images and products from EUMETSAT via the EUMETCast distribution system. Access to these data has allowed African NHMSs to: i) provide accurate weather forecasts; ii) monitor extreme weather events; and iii) improve disaster management. Six PUMA pilot projects[30] promoted the use of Earth Observation (EO) data beyond meteorological applications, including water resources, agriculture, and environmental management[31].

Subsequent to the PUMA project, the African Monitoring of Environment for Sustainable Development (AMESD) project (2007–2012) extended the use of remote sensing data for environmental and climate monitoring applications. This involved installing new EUMETCast weather observation stations and upgrading the EUMETCast stations implemented under the PUMA project. As a result, AMESD enabled African national and regional institutions – including the NHMSs – to provide decision-makers with the information required to improve their planning and contribute to the long-term sustainable development in the region.

The Monitoring of Environment and Security in Africa (MESA) programme (2013–2018) is currently under implementation, building on the activities of the PUMA and AMESD projects. It will contribute to the Global Monitoring of Environment and Safety (GMES) initiative in Africa. In addition, the objectives of the MESA project are closely linked to the GFCS (see Chapter 3). The main objective of the MESA programme is to support African NHMSs in the development or strengthening of their capacity to deliver appropriate climate and weather information to decision-makers in their countries and regions. MESA particularly focuses on strengthening capacities for the use of EO information in Africa with an emphasis on climate and environment applications[32]. The MESA programme is funded by the 10th European Development Fund (EDF) of the European Union, with a budget of €37 million. Beneficiaries of the MESA programme are 48 countries within five African regions, namely the Economic and Monetary Community of Central Africa (CEMAC), ECOWAS, IGAD, the Indian Ocean Commission (IOC) and the Southern African Development Community (SADC). The African Union Commission is the contracting authority of MESA.

[29] These institutions include: The European Commission, the African Regional Economic Communities, the ACP Secretariat, the African Union Commission and the WMO.
[30] These six pilot projects are underway in the Democratic Republic of Congo, Kenya, Mauritius, Niger, Senegal and South Africa.
[31] EUMETSAT. 2012. EUMETSAT and Africa. European Meteorological Services at the Service of Africa.
[32] http://www.eumetsat.int/website/home/AboutUs/InternationalCooperation/Africa/MonitoringofEnvironmentandSecurityinAfricaMESA/index.html. Accessed on 17 July 2015.

The MESA project is expected to deliver the following results:

- improved and sustainable access by African stakeholders to EO data/information at continental, regional and national levels;
- improved EO data/information services to inform decision-making and planning at continental, regional and national levels;
- improved interchange – geographically and thematically – as well as cooperation among African regions and European partners to promote efficient and integrated information services;
- strengthened political and policy development frameworks to promote active and sustainable participation of African stakeholders in initiatives concerning EO for environment and security; and
- increased knowledge of African stakeholders on EO information – including *inter alia* sources, uses, limitations and policy implications – that will contribute to long-term benefits.

Through its dissemination system, EUMETCast-Africa users have real-time access to a wide variety of satellite data, including *inter alia*: i) basic data from the WMO; ii) forecast data from the European Centre for Medium-Range Weather Forecasts (ECMWF); and iii) data from the NHMSs of EUMETSAT Member States. Advantages of the EUMETCast system include its user-friendly infrastructure and small cost of obtaining high-quality data, which is made possible through a single receiving station using off-the shelf components. Currently, there are ~400 functioning EUMETCast stations across Africa[33]. EUMETCast-Africa is the African component of GEONETCast[34], which is a global network that disseminates satellite-based data to provide worldwide, continuous access to EO data and environmental information. In addition, GEONETCast is an early success of the Global Earth Observation System of Systems (GEOSS), which allows global access to affordable EO data[35].

EUMETSAT works closely with its African and international partners to respond to the needs of African policy makers regarding climate and weather information, thereby facilitating the introduction of climate services in Africa. One such collaboration is ClimDev-Africa, a joint initiative of the African Union Commission (AUC), the United Nations Economic Commission for Africa (UNECA) and the African Development Bank. Its objective is to improve climate and weather information in Africa and strengthen the use of such information for decision-making. This will be achieved by improving the analytical capacity, knowledge management and dissemination of activities across Africa.

### *4.2.3. Private companies providing and using satellite data*

In addition to the above-mentioned government-related satellite data providers, private satellite companies have emerged over the past two decades. These companies are using remote sensing techniques to obtain climate and weather data. These data are made available to farmers to assist them with managing and monitoring their crops. An example of such a company is Environmental Analysis and Remote Sensing (EARS)[36], which has been involved in several agricultural projects in East and West Africa. EARS has, in particular, developed an index insurance for reducing agricultural risks[37]. Since 2012, EARS has been involved in piloting a project in Senegal using different climate data collection techniques, including satellites, to improve data quality for Weather Index-Based Insurance (WIBI). After the first year, the project demonstrated that there is considerable potential for improvement to calibrate the weather indices by: i) incorporating additional ground data made available by the project; ii) interacting directly with local experts – including NHMS staff; and iii) integrating different methodologies[38]. A more detailed description on how private satellite companies operate is described in the box below using EARS as example.

[33] EUMETSAT. 2012. EUMETSAT and Africa. European Meteorological Services at the Service of Africa.
[34] http://www.devcocast.eu/ViewContent.do?pageId=110. Accessed on 16 July 2015.
[35] http://www.eumetsat.int/website/home/AboutUs/InternationalCooperation/CEOSGCOSandGEO/index.html. Accessed on 16 July 2015.
[36] http://www.ears.nl/. Accessed 23 August 2015.
[37] Personal conversation with Mr A. Rosema on 28 September 2015.
[38] IFAD. 2015. Remote sensing for index insurance. Findings and lessons so far.

***EARS***

**Background**

Environmental Analysis and Remote Sensing (EARS) is a remote sensing and geo-informatics company that has developed its own innovative technology, known as the Energy and Water Balance Monitoring System (EWBMS). This technology is used to derive and map temperature, radiation, evapotranspiration, cloudiness and rainfall data from Meteosat data[1]. EARS has processed 33 years of Meteosat data on evaporation and precipitation data fields that cover the entire African continent at a 3 km spatial scale, with daily temporal resolution. This Meteosat reception and processing continues in real time at the head-office. In addition, EARS receives data from the WMO Global Telecommunication System for calibration and validation purposes. Based on the aforementioned data, EARS has developed systems and services for river flow forecasting, drought monitoring, crop yield forecasting and crop index insurance.

**The model**

Since 2009, EARS has been developing a micro-crop index insurance called the Food Early Solutions for Africa (FESA). This initiative aims to insure farmers against damage caused by drought, extreme precipitation and winter or night frost. Once farmers have signed-up for the insurance, EARS will use the Meteosat receiving system to: i) monitor the index during the growing season; ii) calculate pay-outs; and iii) report the results. The project was co-funded by Ministry of Foreign Affairs of the Netherlands as a contribution to achieving the UN Millennium goals.

**Benefits**

FESA has been developing and providing low-cost drought and excessive precipitation insurance in Senegal, Mali, Burkina Faso, Benin, Kenya, Tanzania, Rwanda, Uganda, Malawi, Mozambique and Botswana. However, as with many micro-insurance schemes, the model was found to not be commercially viable without public sector funding (see also Chapter 7 on insurance).

**Upscaling, and satellite data versus ground weather stations**

Through the use of Meteosat-derived data, full spatial coverage and long-time series can be provided in Africa via EARS. These satellite-derived data can address the current geographical gaps that exist between meteorological ground stations in Africa. However, the investment, operation and maintenance of these satellites is expensive. To provide the long time series that are required for a proper risk assessment and insurance design, the satellite data need to be complemented by real-time data from on-the-ground weather stations.

**Relationship with the NHMSs**

EARS is a provider of tailored climate information systems and products that are generated from Meteostat-derived data. EARS therefore does not use data from the NHMSs. As a result, the company has only incidental relationships with NHMSs, often with the objective to obtain data that is not available through the WMO-Global Telecommunication System to validate satellite weather data.

## 4.3 Weather stations

NHMSs operate their own network of on-the-ground weather stations to gather climate and weather information. This network is complimented by various other weather station networks.

With increasing access to the internet and a growing demand for localised weather information, research institutions, businesses and individuals may choose to generate weather data by purchasing their own

weather station. NHMSs can collaborate with these research institutes, businesses and individuals to generate additional climate and weather information at the national level. Localised climate and weather information from these sources is voluntarily sent to a national server and the NHMS. These data improve both the quantity and quality (finer-resolution) of the climate and weather information.

An example of private research institutions, businesses and individuals sharing information with an NHMS is the Citizen Weather Observer Programme (CWOP) in the U.S.A. CWOP is a public-private partnership between NOAA and the private owners of weather stations. The CWOP's three main goals include: i) collecting weather data contributed by citizens; ii) making these data available for weather services; and iii) providing feedback to the data contributors and establish tools to monitor and evaluate the data quality. The CWOP allows owners of personal weather stations to share live data with interested parties, including *inter alia*: i) the NHMS; ii) universities; and iii) emergency services[39]. Although these weather stations may not comply with WMO requirements, they do assist the NOAA to better calibrate their existing data.

A different collaboration exists between the Kenya Meteorological Service (KMS), the TU Delft, Netherlands and Oregon State University, United States. These entities have signed a Memorandum of Understanding (MoU) as a framework for long-term collaboration for the Trans-African Hydro-Meteorological Observatory (TAHMO) project. TAHMO's overall mission is to improve sub-Saharan Africa's capacity for hydro-meteorological monitoring[40]. In particular, the TAHMO project aims to build a dense network of hydro-meteorological monitoring stations – one every 30 km – in sub-Saharan Africa, by installing 20,000 stations in school grounds. To achieve this mission, the objective of the collaboration with the KMS is the development of a network of Automatic Weather Stations (AWS) in school grounds in Kenya. To promote the sustainability of the project, the use and maintenance of the weather stations will be integrated into the educational curriculum. These objectives align with the mission of KMS to: i) facilitate accessible meteorological information and services; and ii) infuse scientific knowledge to foster socio-economic growth and development.

In 2015, TAHMO won the Global Resilience Challenge and received funding to develop an early warning system (EWS) in Uganda against severe climate-induced hazards. Over the next two years, this EWS will be implemented to provide critical warnings to fishermen on Lake Victoria, where ~5,000 people drown annually as a result of severe weather. TAHMO will be developing the system together with Earth Networks, African Centres for Lightning and Electromagnetics (ACLE), Climate Change Adaptation Innovation (CHAI), and Human Networks International (HNI).[41]

## 4.4 Concluding comments

It is increasingly recognised that a combination of improved: i) (globally) available satellite proxy data; and ii) sophisticated modelling tools and techniques, are reducing the barriers that prevent private weather companies from entering the weather market for tailored climate and weather products. To stay competitive in the weather market, NHMSs should capitalise on new weather satellite technologies and expand their on-the-ground weather station network.

An example of new weather satellite technologies is new remote sensing platforms and solutions, such as those offered through NOAA and EUMETSAT. These platforms are improving in quality and affordability, thereby offering new opportunities to relatively under-resourced NHMSs. The main advantages of these remote sensing platforms include *inter alia*: i) improved spatial convergence; ii) improved sensor sets; and iii) historical satellite rainfall estimates that extend back 30 years[42].

[39] http://www.srh.noaa.gov/epz/?n=cwopepz 31 August 2015.
[40] http://www.tudelft.nl/en/current/latest-news/article/detail/mou-kenya-meteorological-service-en-tu-delftosu-weerstationproject-tahmo/. Accessed on 20 July 2015.
[41] http://tahmo.org/news/. Accessed on 3 December 2015.
[42] estimates that can be considerably improved if subjected to detailed modelling using modern high power computing methods

Although satellite data are available over most parts of the world and provide enhanced spatial and temporal resolutions, a ground observation network is still required for validating and calibrating climate forecasting models[43]. A combination of ground-based observations with satellite and/or model information is therefore recommended to overcome spatial and temporal gaps in national climate records, leading ultimately to improved quality of all tailored weather products.

Initiatives like CWOP in the U.S.A and TAHMO in Kenya are both useful examples of economical options for NHMSs to expand their on-the-ground weather station networks. When aligned with a wider national development plan to improve the national climate record, NHMSs are able to improve their ability to produce high quality, accurate climate and weather information.

[43] Dinku, T. et al. 2013. Combined use of satellite estimates and rain gauge observations to generate high-quality historical rainfall time series over Ethiopia. In: International Journal of Meteorology. Volume 34 (7): p2489–2504.

# 5. STATUS QUO OF NHMSs

This chapter provides an overview of the current financial and technical capacity of the NHMSs in the 11 African countries supported by the CIRDA programme to generate climate and weather information and engage with the private sector. It also summarises opportunities for further private sector engagement in the countries supported by the CIRDA programme.

## 5.1 The current capacity of NHMSs in countries supported by the CIRDA programme to engage with the private sector

Eastern and southern Africa

Tanzania and Zambia have the technical, institutional and financial capacity to generate income from that sale of goods and services to the private sector (see Table 5.1). In addition, these countries exhibit great potential to increase their revenue through partnerships with the private sector. This potential is a result of a positive enabling environment for public-private partnerships (PPPs), as well as effective communication channels to disseminate information. In addition, the staff of the NHMSs in Tanzania and Zambia have adequate technical capacity to analyse and package weather data, which provides the opportunity to start engaging with end users to develop tailored products and services.

While the NHMSs in Uganda, Malawi and Ethiopia are functional, their capacity to generate income from sales of goods and services to the private sector is hindered by the following challenges: i) limited technical capacity to generate tailored products and services to meet the specific needs of private sector clients; and ii) an inadequate political framework for regulating PPPs (see Table 5.1). These challenges are exacerbated by limited funding from their governments. The network of weather observation stations in these countries are also often not extensive enough to generate fine-scale weather data (see Table 5.1).

West Africa

An analysis of the status quo of NHMSs in West African countries that are supported by the CIRDA programme suggests that the capacity of the majority of these NHMSs to generate income from their products and services is limited, and hindered by: i) limited technical capacity to generate goods and services; ii) inadequate access to information; and iii) restricted funding (see Table 5.1). These limitations are often associated with past or present political instability. For example, most of Sierra Leone's infrastructure was destroyed during their long civil war, and there is currently not enough funding allocated by the government to Sierra Leone's NHMS to buy or restore weather observation equipment. The problem of inadequate government funding is also pervasive in the other West African countries supported by the CIRDA programme, and often limits the capacity of NHMSs to maintain weather stations and train staff. One exception is Burkina Faso, where weather stations are relatively well-distributed across the country and climate data are digitised. This allows the data generated by the NHMS to be accurate and readily accessible for the private sector end users (see Table 5.1). As a result, businesses across a variety of sectors in Burkina Faso have indicated a willingness to form a partnership with the NHMS.

There is scope in some West African countries to develop their NHMSs over time, but deep levels of engagement with the private sector are probably not an immediate priority or practical. However, there are plans in place to promote the development of the NHMSs in some of these countries. For example, while the technical and financial capacity of the NHMS in the Gambia and Sierra Leone is limited, these countries are implementing programmes and plans to develop their NHMSs, thereby increasing their future potential for PPPs.

For the less developed countries supported by the CIRDA programme in West Africa – Benin, Liberia and Sao Tome and Principe – the following approach is recommended:

- regulatory reform to pave the way for greater participation with the private sector, in the medium term;
- building the case for investment in the NHMS, especially from national treasuries;
- capacity building of NHMS staff to sustain, monitor and expand their ground observation network; and
- growing existing income streams such as aviation, and focusing on public sector clients for example the Departments of Fisheries, Agriculture, Forestry, Water and Health.

*Table 5.1.* ***Summary of NHMS capacity in the 11 African countries supported by the CIRDA programme[44].***

| | **Technical capacity** | **Enabling policy environment** | **Financial Capacity** | **Potential for PPPs** |
|---|---|---|---|---|
| **Eastern and Southern Africa** | | | | |
| **Zambia** | • 41 weather stations, but only ~50% are operational;<br>• 10 professional staff; and<br>• 170 technical staff. | National Meteorology Policy (2013) aims to implement appropriate strategies and develop the legal and institutional framework to support the self-sustainability of the NHMS through cost recovery on some selected products and services.<br><br>The Meteorological Bill (2015) allows The National Meteorological Service in Zambia (ZNMA) to introduce marketable products and services. | The total budget of ZNMA is ~US$5,000, with less than 10% of this funding derived from non-governmental organisations. | The Meteorological Bill promotes PPPs in the development of meteorological services, particularly for the following sectors: i) aviation; ii) agriculture; iii) water resources management; iv) education and research; v) health; and vi) building and civil engineering. |
| **Uganda** | • 12 synoptic stations;<br>• 18 agrometeorological stations; and<br>• 60 operational rainfall stations. | UNMA Act (2012) enables meteorological information to be sold for profit. | The NHMS receives limited funding from the Government of Uganda. | There is scope for PPP between the NHMS and the private sector. Legally, the NHMS is the sole provider of weather information in the country. Demand for information has been expressed by the private sector – particularly aviation, construction and mining. Currently, there is a cost recovery agreement between the NHMS and Uganda's Civil |

[44] This information was obtained through direct communication with CIRDA Project Managers in each of the 11 countries, country reports that were provided by these individuals and literature surveys.

| | | | | |
|---|---|---|---|---|
| | | | | Aviation Authority (CAA). |
| **Tanzania** | • 26 operational surface synoptic stations;<br>• 5 operational AWS;<br>• 16 operational agrometeorological stations;<br>• 60 operational meteorological stations;<br>• 500 operational weather stations; and<br>• 1 operational upper air station. | There is a Five-Year Plan for the enhancement of meteorological services for sustainable, socio-economic development in Tanzania. | Funding is primarily provided by the government, but the NHMS does derive nominal income from the aviation sector. | There is a dedicated PPP unit in the Country (Tanzania Investment Centre). |
| **Malawi** | • 22 meteorological stations;<br>• 21 subsidiary agrometeorological stations; and<br>• ~400 rainfall stations. | The enabling environment does not support the advancement of the NHMS as there is limited integration of meteorology in national development plans. | Limited government funding. | The Public-private partnership Bill and Public-private partnership Commission facilitate PPPs in Malawi. |
| **Ethiopia** | • 1,200 meteorological stations;<br>• 25 AWS;<br>• Upper air observation unit' and<br>• AWSs at airports. | Limited | Limited government funding. This funding is not sufficient to cover costs but charging for services is not permitted by law. | Opportunities for PPPs in Ethiopia are limited, but private companies are legally required to share climate and weather data with the NHMS. |
| **West Africa** | | | | |
| **Benin** | • 10 AWS;<br>• 3 synoptic stations; and<br>• 7 agro-climatological stations. | Limited | Limited government funding to cover costs. | There is a legal framework in place to promote PPPs. Currently, the products and services generated for private interest are charged for. |
| **Burkina Faso** | • 160 meteorological stations. | Limited | The main source of income is from the aviation sector – which is primarily used to maintain the network of observation | There is no dedicated PPP unit in Burkina Faso. However, the private sector can approach the chamber of commerce to indicate that they are interested in forming a partnership. If the private sector directly approaches |

| | | | | |
|---|---|---|---|---|
| | | | stations and pay Department of Meteorology (DOM) staff. | the NHMS and can come to an agreement, this process is not needed and private sector and the NHMS can develop a MoU. |
| **Sao Tome and Principe** | • 2 synoptic stations;<br>• 7 AWS;<br>• 16 classical monitoring stations; and<br>• 7 rain gauges. | The existing enabling environment allows for, but limits, direct interactions between the NHMS and the private sector. | Revenue is generated through services provided to the aviation sector, although a positive enabling environment for private sector interaction – particularly, with the fisheries and financial sector – will increase this revenue Currently, the revenue generated from sale of services to the aviation sector is ~US$75,000 per annum. | The legal framework for PPPs is fragile as a result of political instability. In addition, challenges relating to land tenure have prohibited partnerships between agri-businesses and the public sector. However, such partnerships between agri-businesses and the public sector are potentially beneficial to improving food security in the country by providing early warnings of hazardous weather events. |
| **Sierra Leone** | The technical capacity of Sierra Leone's NHMS is limited as weather monitoring stations have been damaged and become non-functional during the civil war. | Sierra Leone is in the process of strengthening its climate and weather services through the following plans and programmes:<br>• Meteorological Services Strategic Plan (2011–2015); and<br>• Five-Year Capacity Development and Service Delivery Programme. | There is limited government funding for the NHMS as expenditure is focused on rebuilding after the civil war. Similarly, inoperative weather stations mean that the NHMS cannot sell data or products to the private sector to | Limited because of the absence of policies. |

| | | | | |
|---|---|---|---|---|
| | | | generate income. | |
| **The Gambia** | • 3 AWS;<br>• 1 MSG Satellite Receiving Station;<br>• 10 automatic water level, temperature and conductivity measurement instruments; and<br>• 37 ground water monitoring instruments. | An act is being written that will establish the NHMS as a semi-autonomous organisation, thereby enabling engagement with the private sector. | There is limited government funding. However, the NHMS has submitted a draft requesting permission to charge for their services to increase their income. | A PPP exists between the NHMS and companies, who pay for broadcasting by advertising their product before and after the weather forecast. |
| **Liberia** | Liberia has the following staff and equipment spread over four ministries and agencies:<br>• 6 meteorologists;<br>• 11 meteorological technicians;<br>• 6 meteorological technicians in training;<br>• five hydrometric stations;<br>• six rainfall stations<br>• one meteorological training station;<br>• one hydrometric training station;<br>• 3 manual rain gauges;<br>• 1 Automatic Weather Observing Station;<br>• 1 outdated Aeronautical Message Processor System (AMPS);<br>• 1 MSG-PUMA station which has been upgraded to PUMA Synergies;<br>• 1 obsolete Stevenson Screen containing dry and wet bulb thermometers as well as maximum and minimum thermometers; and<br>• 1 wind vane for measuring wind | Draft legislation for the establishment of a National Meteorological Agency (NMA) has been validated by stakeholders and is in review for enactment into law.<br><br>A MoU has been signed with the Liberian Airport Authority to facilitate the setup of a National Meteorological Centre. | The main source of funding is from the Government of Liberia, but additional financing is provided by international entities. | The NHMS is not allowed to engage in commercial activities. |

| | | | | |
|---|---|---|---|---|
| | direction and speed. | | | |

# 5.2 Challenges and opportunities for weather information generation and private sector engagement by NHMSs in the countries supported by the CIRDA programme

## *5.2.1 Main challenges for the NHMSs*

There are six challenges identified that prevent the NHMSs in the countries supported by the CIRDA programme from producing and disseminating weather information in an accurate and timely manner[45].

Firstly, many NHMSs have insufficient technical capacity to maintain existing weather stations – particularly those in remote areas. In addition, roads to remote locations are poorly developed – compared to those in Europe and the USA – which limits accessibility to these stations for maintenance. One way of overcoming these challenges is to place weather stations at locations that are easy to reach, such as schools (see Chapter 4). This will improve the functioning and sustainability of weather stations, as schools are easily accessible and school staff can be trained to maintain these stations. Innovative alternative initiatives – such as placing Automatic Weather Stations on existing mobile network facilities – have also been developed. Through these initiatives, the NHMS observation network benefits from the power, security, telecoms transmission capability and technical maintenance capacity of the mobile operator (see Chapter 9).

The second challenge faced by NHMSs is the limited integration of new technologies into producing and analysing data from weather stations. Without new technology, the accuracy and reliability of the data produced by the NHMSs is reduced. To improve the quality of data, the NHMS staff would need to be trained intensively to install and maintain new hardware technologies as well as on the use of software technologies for data analysis.

Thirdly, the calibration of sensors on the weather stations cannot be done within the countries supported by the CIRDA programme. Instead, this typically takes place in Europe or the USA. Sending this equipment to be calibrated is costly and leads to gaps in the observation time series.

Fourthly, the installation, monitoring and maintenance of weather stations are not consistent within the countries supported by the CIRDA programme. The installation – which includes siting and exposure – of weather stations (either NHMS or private sector) should ideally fulfil certain minimum standards to achieve WMO-mandated consistency. Although it would be preferable for all weather stations to adhere to WMO standards, this is not always feasible. The weather market therefore approves of weather stations in these countries that are not compliant with WMO standards, provided the stations are installed consistently within the country. There are several approaches to creating this consistency among weather stations. For example, in Tanzania, the government has made it obligatory that weather stations – from both the public and private sector – be installed by the NHMS. In addition, NHMS staff in Tanzania are trained to maintain these stations[46]. However, this approach is challenging in many other countries supported by the CIRDA programme, as the NHMSs have limited capacity to deploy and maintain their own networks. It is therefore unlikely that the NHMSs will have the capacity to manage a commercial operation.

Fifthly, the approach required by the NHMSs to engage with the private sector is different to that required for engaging with the public sector. Creating dialogue and forging strategic partnerships with the private sector will require additional skills that need to be acquired by the NHMSs – for example, rapid analysis and

[45] Personal conversation with Mr N. van der Giesen, TAHMO on 17 September 2015.
[46] Personal conversation with Mr E. Mukhala, WMO on 13 September 2015.

processing of weather data, with emphasise being placed on price and value. Experience from New Zealand (MetraWeather) indicates that it can take ~10 years for these behaviours and practises to become established within a NHMS or its private sector agency[47] (see Chapter 9 for more detail).

Lastly, considering that most NHMSs in the countries supported by the CIRDA programme rely primarily on restricted government funding, and this funding is often inadequate, their capacity to develop innovative products and services is limited. Consequently, competing with the private sector for revenue will be a challenge for NHMSs. In particular, unlike the private sector, many NHMSs do not have the financial capacity to pay for the training, maintenance and subscriptions for forecasting services. In addition, as most NHMSs in countries supported by the CIRDA programme are still developing their capacity in the climate and weather sector – where the core functions of the NHMSs themselves are under pressure – it may not be feasible to divert human capital to state-owned or even non-state entities at this time.

A method for addressing the six challenges above has been exemplified in the USA. Since 1946, when the first private weather companies started operation, the commercial weather sector within the USA has grown to ~350 companies[48]. This rapid growth of the commercial weather market is largely a result of the US government providing free and open access weather data. It is difficult to calculate the size of the entire climate and weather-related industry, since many of these companies are privately held. However, in 2013, the University Corporation for Atmospheric Research (UCAR) estimated gross sales of weather products and services at US$3 billion per annum, and the value of the entire industry at US$6 billion per annum. In 2015, the value of the weather sector was conservatively estimated at US$1.5 billion, with a ~30% predicted growth (US$2 billion) per annum by 2020[49]. The weather market in the USA ranges from small consulting companies – "value adders" – to larger commercial groups "forecasters" that includes media firms such as The Weather Company[50], which serves diverse markets including energy, agriculture, building, insurance and other sectors[51].

It is noteworthy that the entire private weather industry in the USA is supported by the free sharing of data by the federal service. This is frequently cited as a leading example of how the government can create and support private commerce by making public data openly and freely available[52]. This is pertinent for countries supported by the CIRDA programme because in the long-term, sharing of weather data promotes market development – which is advantageous for NHMSs that are developing products and services that can be sold for profit. However, at present, there is tension between public and private participants in several countries supported by the CIRDA programme, with many in the public sector viewing the NHMS as competing unfairly with the private sector[53].

One of the reasons that NHMSs are viewed as competing unfairly with the private sector is that current legislation in some countries defines the role of NHMSs as the sole authority and provider of tailored climate and weather information products. This legislation is however, unlikely to be over the long-term because restricting the distribution of climate and weather information in these countries: i) is unenforceable in the digital age; ii) reduces competition for products and services that are in the national interest, and iii) will prove to be counter-productive to the NHMSs in the long run. It also contradicts WMO Resolution 40, which urges members to strengthen their commitment to the free and unrestricted exchange of meteorological and related data and products[54].

[47] Personal conversation with Mr P Kreft and Mr N. Henry, MetraWeather on 5 November 2015.
[48] Craft, Erik. 1999. Private Weather Organisations and the Founding of the United States Weather Bureau. Journal of Economic History 59, no. 4: p1063- 1071.
[49] American Meteorological Society
[50] The company is also owner of "The Weather Channel", which is available in over 100 million homes.
[51] http://knowledge.wharton.upenn.edu/article/todays-forecast-for-the-weather-business-increased-revenues-and-a-focus-on-innovation/. Accessed 17 August 2015.
[52] The assets are in the public domain and thus available to anyone in accordance with United States law.
[53] Personal conversation with Ms H. Miller-Wise, ESOKO on 7 December 2015.
[54] https://www.wmo.int/pages/about/Resolution40_en.html. Accessed on 5 February 2016.

### 5.2.2 Competitive advantages favouring the NHMS

For NHMSs in general to compete with private weather companies, they need to highlight their competitive advantage. The competitive advantage of the NHMS includes *inter alia*:

i) having physical infrastructure on-the-ground (which can greatly increase the accuracy and resolution of climate and weather information;
ii) providing services – such as EWS – for the government to guarantee public safety in case of severe weather events;
iii) providing continuity and being neutral[55];
iv) having a dedicated development budget;
v) having larger datasets compared with private weather companies;
vi) being supported by the WMO;
vii) being ICAO designated providers of Aeronautical Meteorological Information (which is a barrier to private sector penetration of the aviation weather market);
viii) being the *de facto* keepers of the national climate record; and
ix) having access to policymakers and legislators.

The competitive advantages of the NHMSs should be used to define their roles in the private sector. If NHMSs capitalise on these advantages and help shape the emerging markets for climate and weather information in their respective countries, then the private sector, including private weather companies and other product development and commercialization entities, can become allies that share their revenue streams and support long-term financial sustainability.

### 5.2.3 Existing opportunities for NHMSs to increase their revenue

Although there are limitations that prohibit NHMSs from increasing their financial capacity in some countries supported by the CIRDA programme – including stipulations that prevent the sale of their products and services – there are opportunities for NHMSs to generate profit. For example, NHMSs can assist private weather companies because these companies often have limited budgets for developing their products and services, and their datasets are often small. Therefore, by selling data to the private sector, the cost recovery of datasets produced by NHMSs can be increased. In addition, since the NHMSs do not hold any intellectual property rights or licencing, a trustworthy relationship can be developed with private weather companies[56].

[55] Personal conversation with Mr B. Wichers-Schreur, KNMI on 21 October 2015.
[56] *Ibid.*

## 5.3 Overall readiness of the countries supported by the CIRDA programme to engage with the private sector

Table 5.2 below lists the factors that influence the readiness of each CIRDA country to engage effectively with the private sector. Countries were classified into three main categories; i) '**Ready to engage with selected private sector companies**' (countries in this group included Tanzania, Zambia and Burkina Faso); ii) '**Moderate capacity building required before extensive engagement with the private sector**' (Benin, Ethiopia, the Gambia, Malawi and Uganda); and iii) '**Intensive capacity building required before extensive engagement with the private sector**' (Liberia, Sao Tome and Principe, and Sierra Leone). Colour coding is used to indicate the country's stage of readiness – where green indicates the greatest state of readiness and red the least. This information has been derived from national documents as well as interviews with representatives of the NHMSs, Non-Governmental Organisations, the private sector and universities.

**Table 5.2.** Country Readiness Assessments for the 11 CIRDA NHMS offices.

| | Benin | Burkina Faso | Ethiopia | The Gambia | Liberia | Malawi | Sao Tome and Principe | Sierra Leone | Tanzania | Uganda | Zambia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Political & Policy Context** | | | | | | | | | | | |
| **Ease of doing business[57] (1=easiest)** | 7 | 10 | 3 | 4 | 11 | 9 | 8 | 5 | 2 | 6 | 1 |
| **PPP legislation** | X | | | | | X | | | X | X | X |
| **PPP unit** | | | | | | X | | | | X | |
| **Decentralised system** | | X | | | | | | | X | | |
| **Semi-autonomous** | | | | | | | | | X | | |
| **Permitted to charge for data** | X | | X | | | | | | X | | |
| **Integration of climate change into national plans and strategies** | | X | | | | | | X | | | X |
| **Trusted and effective communication channels to disseminate weather information** | | X | | X | | X | | | | X | X |

[57] World Bank. 2014. World Development Indicators. http://data.worldbank.org/indicator/IC.BUS.EASE.XQ/countries/1W?display=default. Accessed on 18 August 2015. A high ranking (a low numerical rank) means that the regulatory environment is conducive to business operation.

| **NHMS Capacity** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Maintenance of historical data** | | X | X | | | | | | X | | |
| **Technical capacity to analyse data** | | X | X | | | X | | | X | | |
| **Well-distributed network of national weather stations** | | X | X | | | | | | | | |
| **Adequate equipment for forecasting** | | | | | | | | | | | X |
| **Digitised data** | | X | | | | | | | | X | |
| **Accurate weather information** | | | | | | | | X | | | |
| **Motivated staff** | | X | | | | X | | | X | | X |
| **Coordination and information-sharing with other institutions** | | | | X | | X | | X | | | |
| **Understanding of user needs** | | | | | | | | | | | |
| **Ability to provide EWS** | | X | | X | | | | | X | | X |
| **Relationship with private sector** | | | | | | | | | | | |
| **Supplies data to NHMS from own weather station** | | | | X | | X | | | | X | X |
| **Willingness to form partnership with NHMS** | | | | | | | | | | | |
| • **Aviation** | | X | | | | | | | X | X | X |
| • **Agriculture** | | X | X | | | | | | | X | X |
| • **Mobile** | | X | | X | | | | | X | X | |
| • **Energy** | | | | | | | | | | | X |
| • **Fisheries / marine** | | | | X | | | X | | | | |
| • **Insurance** | | X | X | | | | X | | | X | X |
| • **Construction** | | | | | | | | | | | X |

## Revenue-Generating Opportunities Through Tailored Weather Information Products

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Currently purchasing NHMS products and services** | | | | | | | | | | | |
| • **Aviation** | | X | | | X | | X | | X | X | X |
| • **Agriculture** | | | | | | | | | | | |
| • **Mobile** | | | | | | | | | | | |
| • **Insurance** | | X | | | | | | | | | |
| **Last Mile relationships** | | | | | | | | | | | |
| **Involvement of local communities in collecting data** | | X | | | | | | | X | | X |

# 6. PRIVATE SECTOR CLIMATE AND WEATHER INFORMATION PROVIDERS

Private weather companies provide climate services tailored to the specific needs of the client. These clients include individuals and companies from a variety of sectors, including *inter alia* agriculture, fisheries, mining, mobile telephony, and transport. In Africa, paying for climate and weather products and services is novel as the public perception (and historical approach) has been that climate and weather information is, and should be, provided for free. As a result of this perception – as well as limited government funding – NHMSs in Africa are facing considerable financial challenges in providing adequate weather information to the public and private sector.

This chapter will examine the provision of climate and weather information from the perspective of the private sector. This will be achieved by analysing existing relationships between private weather companies and the NHMSs in developed countries, as well as business-to-business relationships between private weather providers and end users.

## 6.1 Market presence, vision and commercial interest

Over the last two decades, there has been a steady global increase in the number of private weather companies, but these operate almost entirely in developed economies. The reason for this expansion of private weather companies has been the recognition of a gap in the market providing tailored weather products and services. This gap has emerged from an increase in demand for more localised and specialised weather forecasts by individuals and consumers of private sector weather information in developed countries. The NHMSs in these countries found that their mandates, operational foci, and human and financial resources were inadequate in terms of providing specialised and localised weather products. Addressing these challenges would have entailed a considerable and costly expansion of the ground observation network. Moreover, most NHMSs in developed countries are not mandated to sell tailored weather products and services like private weather companies can. This is because the provision of weather information is considered a free service that promotes public safety. Private weather companies have as a result filled in this gap by providing localised weather information to specific sectors or individuals. These companies are entirely market focused, and are structured in such a way that they do not carry the human resourcing and infrastructure overheads like the NHMS does. This allows them to be flexible, and to invest a greater share of their resources in developing the private sector market.

Private weather companies can be divided into two broad categories. Firstly, there are those that specialise in forecasts –"forecasters" - who compete directly with NHMS. Secondly, there are companies that specialise in adding value to existing data, as well as the installation and operation of specialised technologies[58] – "value adders". With the exception of AfricaWeather in South Africa, there are currently no other African private weather companies[59]. In recent years, international private weather companies that operate outside Africa – including Earth Networks and Weatherzone – have entered the African weather market. In the context of climate change, these companies have recognised the need for more accurate weather information as well as early warnings for severe weather. The vision of these private weather companies includes: i) expanding their current market to provide and sell more weather products and services; ii) building the capacity of the NHMS staff in the African countries to improve the quality of the observation network; and iii) analysing the data generated by the NHMS to improve the weather products and services.

The expansion of the commercial weather market is largely driven by the extent to which private weather companies are able to undertake market and business development activities. Although weather affects many economic activities, tailored weather information is not seen as a commodity and is not typically

[58] Such specialised technologies include for example lightning detection equipment.
[59] Personal conversation with Georgie George, Rob Daneel (Cairn Aviation) and Charles Solomon (Weather zone).

demand driven. Many private weather companies therefore emphasise the extent to which they need to conceptualise, as well as develop, the business or market opportunity. This is a lengthy process, sometimes taking as long as 5 years[60]. Following this, the company can work with the target customers to develop the opportunity and convert it into a product. The private weather companies thus need to develop both the demand **and** the supply of their products.

### *6.1.1 The relation between NHMS and private sector climate data providers*

Private weather companies in the USA and Europe generally derive basic weather information from the NHMS and complement this with satellite images and radar information from institutions such as EUMETSAT and NOAA (see Chapter 4). To provide localised weather information – as requested by specific sectors and individuals – private weather companies also frequently invest in their own weather stations. These weather stations often comply with the WMO standards, but in some cases the weather stations do not meet all the criteria – for example, the data is not fed into the Global Telecommunication Service network. Even so, these weather stations still provide reliable data. In the USA and Europe, data generated by private weather stations are fed into the overall database of the NHMS to calibrate weather forecasting models thereby making the weather information from both parties more reliable.

Private weather companies have the potential to complement the NHMS by providing localised weather information, thereby increasing the overall accuracy and provision of weather information to the public. To avoid the potential for competition between the NHMS and private weather companies, clear mandates have to be established to define the specific roles and responsibilities of each party. For example, in the Netherlands, after the commercial branch (Infoplaza) split from the Royal Dutch Meteorological Institute (KNMI) and became private, the Dutch government developed a law outlining clear roles and responsibilities for each party with a strict separation between government and the private market. As a result, the KNMI works for the national government, focusing on: i) monitoring the weather at the national level; ii) conducting research; iii) issuing early warnings for weather hazards; and iv) developing and maintaining the historical database[61]. The private weather companies in the Netherlands complement these roles and responsibilities by developing tailored weather products and services for local governments, the private sector and individuals[62]. This use of regulation as a tool for clarifying the roles of public and private weather is further elaborated on in Chapter 9 and the case study on Infoplaza in Annex C6.

Compared with the NHMSs in developed countries, most NHMSs in Africa have limited technical capacity and equipment to provide basic weather information and services to the public[63]. It is therefore likely and easier for end users to bypass the NHMSs to get better products from private sector suppliers. Moreover – because of the large size of most African countries – the number of weather observation stations required to provide localised weather information is greater than what is required by the average European country. In addition, limited financial resources tend to hinder investment in new technologies that will improve the accuracy of the weather information generated by NHMSs in Africa. Private weather companies have the potential to fill this financing gap and provide assistance to the NHMS by supplying modern technology that will improve the quality of information that is generated. For example, Earth Networks is assisting the NHMS in Guinea (see case study in Annex C6), and installing lightning detection monitoring infrastructure in Uganda.

### *6.1.2 The relationships between private sector climate data providers and consumers*

The data produced by the NHMSs in Africa is often generic and freely available to the public. However, there is limited capacity of NHMS staff to use modern technologies to develop and disseminate tailored products

[60] Personal conversation with Mr Jeremy Usher with reference to WeatherNews Inc., Jan 2016.
[61] Personal conversation with Mr Wichers-Schreur from the KNMI on 21 October 2015.
[62] For more details, please refer to the text box on KNMI in Chapter 9.
[63] Personal conversations with representatives from the NHMSs in the 11 African countries supported by the CIRDA programme in Addis Ababa between 25 and 28 August 2015.

– derived from these data – to the end users. Several initiatives – e.g. the Statistics In Applied Climatology (SIAC) course supported through the Statistical Services Centre (SSC) at University of Reading[64] – are attempting to address this shortfall, but this remains a work in progress and additional training is required. As an example, in the USA, the National Council of Industrial Meteorologists offers an online course to the NHMS on public and private sector collaboration for producing tailored weather products for the private sector.

On the other hand, private weather companies most frequently produce tailored climate and weather information for specific clients. Once generated by the private sector data providers (see chapter 4), the weather data is disseminated through various platforms – including *inter alia* mobile phones and internet – according to the needs and demands of clients. This dissemination can be done by investing in *inter alia* i) innovative technology; ii) resilient infrastructure; and iii) improved information systems[65] In many cases, weather information for special sectors such as wind energy and transport companies is generated and directly transmitted to representatives of these sectors. Value-added services –including information on crop conditions, diseases and pests for agriculture – can be provided[66] in addition to localised weather forecasts. Such value-added services create opportunities for the private sector to develop additional channels through which such information can be disseminated. The private sector can therefore be regarded as a "supplier of innovative goods and services" in the climate and weather context.

## 6.2 Case studies of private weather companies

See Annex C6 for case studies on Earth Networks, Meteogroup, Speedwell Weather, Infoplaza and WeatherNews.

[64] http://www.reading.ac.uk/ssc/training/siac.php/. Accessed 13 September 2015.
[65] Clements, J. Assessing the Economics of Weather, Climate, and Hydrological Services.
[66] http://www.business-standard.com/article/economy-policy/weather-info-private-forecasters-step-in-where-met-office-falters-112092302006_1.html. Accessed 18 August 2015.

# 7. PRIVATE AND PUBLIC SECTOR CONSUMERS AND USERS OF CLIMATE AND WEATHER INFORMATION

This chapter presents a summary of the private and public users of climate and weather information. For further details, please refer to Annex C7.

## 7.1 Consumers of climate and weather information

The weather market is diverse, with demand for tailored climate and weather products from businesses (ranging from small enterprises to multi-nationals), government (agencies, departments and institutions), NGOs, and individuals. This demand for tailored products is a result of the direct and indirect impacts of climate and weather on many economic activities. Therefore, the potential market for a provider of tailored climate and weather products is large — for example, the private weather market in the USA is now worth between US$1.5–3.0 billion per year.

Businesses, particularly in the transport, energy, forestry, fishing and agriculture sectors, are the primary consumers of climate and weather information. Currently, there are a restricted number of government departments that pay for weather information. To expand the services of the NHMSs and to facilitate engagement with government departments, the WMO and an increasing number of NGOs have recognised that the following is required of the NHMSs: i) close collaboration with the respective government departments; and ii) development of models that ensure that government departments pay (either directly or indirectly) for at least some portion of the value received from climate and weather information provided by the NHMS. These government departments should also be included in the pilot projects on climate services (see Chapter 3) from the outset to facilitate improved institutional arrangements and relationships between them and the NHMS. These improved relationships will also serve businesses operating in the related economic sectors since it will sensitise the government departments to private sector needs and requirements in respect of climate services. Furthermore, dialogue between the NHMS and government departments concerning improved delivery of sector-specific climate services will be initiated.

In addition to businesses, individuals are important consumers of climate and weather information. Most people need timeous and reliable warnings of hazardous weather events (e.g. lightning, floods, windstorms, rainfall and tsunamis), while certain groups of individuals – such as smallholder farmers who are directly exposed to environmental risk and whose livelihoods depend on decision-making concerning climatic conditions – require specific climate and weather information.

## 7.2 Climate-sensitive sectors in countries supported by the CIRDA programme

Certain sectors are more sensitive to changes in climate and weather than others. To determine the most relevant climate-sensitive sectors within countries supported by the CIRDA programme, the economic importance of ten climate-sensitive sectors was assessed (Table 7.1). The ten sectors assessed are those identified as the most climate sensitive by the WMO Global Framework for Climate Services Programme, while the economic importance of each of these sectors was determined through consultations with country representatives and literature reviews.

**Table 7.1.** Economic importance of climate sensitive sectors in the 11 countries supported by the CIRDA programme. Climate-sensitive sectors that are of particular economic importance within a country are marked with an 'X'**.**

| | Benin | Burkina Faso | Ethiopia | The Gambia | Liberia | Malawi | ST and Principe | Sierra Leone | Tanzania | Uganda | Zambia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aviation** | X | X | X | X | X | X | X | X | X | X | X |
| **Agriculture** | X | | X | | | X | | | X | X | X |
| **Mobile Platforms** | | | X | | | | | | X | X | |
| **Insurance** | | X | X | | | X | | | X | X | X |
| **Fishing** | X | | | X | | X | X | X | X | | |
| **Energy** | | X | | | X | | | | | | X |
| **Forestry** | | | | | X | | | | | | |
| **Health** | | | X | | | | | | X | X | |
| **Retail** | | | | | | | | | | | X |
| **Tourism** | | | | X | | | | | X | X | X |
| **Transport** | | X | | | | | X | | X | | |

Based on the results of this assessment, it was determined that aviation, agriculture, mobile platforms, insurance and fishing are the most economically important climate-sensitive sectors in countries supported by the CIRDA programme. These sectors require improved access to climate and weather information in order to develop an appropriate response to the negative effects of climate change. The climate and weather information needs of each of these sectors, and opportunities for NHMSs to provide this information, are further described below.

**Aviation**

Aviation is a major consumer of climate services, with diverse needs extending from airfield nowcasting and forecasting to warnings of other meteorological hazards that are important to aviators. Aviation in Africa is predicted to grow considerably over the coming decades. This prediction is based on the general pattern of economic growth across Africa, which is showing greater growth compared to other continents. Boeing, for example, conservatively predicts a demand of over 1100 of their airplanes in Africa in the next 20 years, worth US$160 billion[67]. This rapid growth in the aviation industry is also mentioned by the International Air Transport Association (IATA), which "forecasts that over the next 20 years, passenger growth in Africa will be the world's fastest."[68] There is thus great potential for climate and weather information products tailored for the aviation sector in Africa.

Carriers, however, will not fly unless there is good nowcast and forecast information for the intended destination, as well as two alternate destinations to fly to. Flying without this information has severe

[67] http://www.engineeringnews.co.za/article/boeing-predicts-strong-aviation-growth-in-africa-2015-07-01. Accessed on 24 August 2015.
[68] http://www.afdb.org/en/news-and-events/article/aviation-the-next-infrastructure-growth-frontier-for-africa-14478/. Accessed on 25 August 2015.

implications for: i) safety; ii) insurance and public liability; iii) brand reputation and risk; and iv) costs via the reserve margin of fuel carried onboard. To ensure safety of air transport, all NHMSs in countries supported by the CIRDA programme are mandatory members of the International Civil Aviation Organisation (ICAO). In addition, the status of NHMSs as recipients of revenues from aviation is reasonably secure – although not absolute – since most countries supported by the CIRDA programme are ICAO-designated providers of Aeronautical Meteorological Information (see Annex C7 for more information).

The use of climate and weather information in aviation is changing rapidly, and is being influenced by the increasingly sophisticated state of communications that exist between aircraft and the ground. Communications improvements are mainly via the satellite Aircraft Communications Addressing and Reporting System (ACARS). ACARS is the dominant digital datalink system for transmission of short messages between aircraft and ground stations via airband radio or, now more commonly, satellite. Service providers (such as Rockwell Collins' AirINC) will integrate weather information from any public or private sources into custom formats for clients (the international carriers) as part of their service offering. Since ACARS are bidirectional, carriers who participate with the WMO AMDAR programme are also able to, in turn, send data from the aircraft meteorological sensors back to the WMO and NHMSs indirectly via ACARS.

The growing availability of private weather company products is also influencing the use of climate and weather information in aviation, as there are now fewer restrictions on who a carrier can source a weather report from (on demand) in flight. For example, South African Airways will use NHMS products, especially for TAFs[69], but are trialling a storm and lightning forecast and warning product from a well-known private weather company[70]. This tailored product is not available over AirINC ACARS yet, so the forecasts cannot be updated in-flight, which is an impediment.

Private aviation is also a consumer of tailored climate and weather information. Services such as OzRunways – and a variety of similar services and products for the private aviator – are potential consumers and re-distributors of climate services products for the aviation sector.

The changing use of climate and weather information in the aviation sector presents both challenges and opportunities for NHMSs to generate greater revenues. To achieve greater revenues, it is recommended that NHMSs should leverage their existing relationship with the aviation sector, which is enabled and partly protected by ICAO, to: i) undertake a comprehensive review of the real costs of delivering meteorological information to aviation (international carriers and private aviation) and based on this revise cost recovery arrangements that are in place; and ii) develop further products that account for the expanding demands of aviation, and which – if not provided by the NHMSs – will almost certainly be provided by the private weather sector in time.

This market assessment also found that, for countries supported by the CIRDA programme, it will be worth investigating the potential to invest in high quality synoptic stations at airfields that will improve overall access to national airspaces. In addition, there is potential to work with private weather companies to develop and package tailored products that meet international standards, and are available over ACARS-based services such as AirINC[71].

NHMSs should also continue their efforts to improve their products and services, since "carriers prefer to use official sources of weather information, but will not rely on them solely"[72]. This suggests that, over time, private weather companies are likely to penetrate this market and command greater shares of total revenue, unless the NHMS act to forestall this disintermediation.

**Agriculture**

[69] A Terminal Aerodrome Forecast (TAF) is a concise statement of the expected meteorological conditions at an airport during a specified period (usually 24 hours).

[70] on a one-year basis

[71] Willie Saayman, South African Airways. Personal communication in January 2016.

[72] Ibid.

The agricultural sector is particularly vulnerable to extreme climatic events. An analysis of 78 natural disasters that occurred across 48 developing countries from 2005–2015 suggested that ~22% of all damages were absorbed by the agricultural sector – including crops, livestock, forestry and fisheries[73] – that resulted in losses of approximately US$26 billion. Another study estimates that by 2100 climate- and weather-related events are expected to cause agricultural losses of up to ~3% of GDP in Western and Central Africa and ~1% in southern Africa[74]. Considering that ~75% of the rural population in Africa depends on the agricultural sector for their livelihoods, agricultural losses have widespread socio-economic consequences. In addition to reducing food security, reduced crop yields result in decreased income for farmers. This decreased income reduces the ability of farmers to invest in agricultural inputs – such as irrigation systems or high quality seeds – which in turn limits productivity and ensures that smallholder farmers remain vulnerable to climate change.

Despite its vulnerability to extreme climatic events, agriculture is widely recognised by economists and politicians as an important contributor to economic development in Africa, and one of the sectors with the greatest potential to reduce inequality and poverty. Governments in countries supported by the CIRDA programme are therefore promoting the expansion of the agricultural sector. The expansion of this sector, combined with its vulnerability to climate and weather events, will result in a growing demand for tailored climate and weather information products.

As the economy in Africa develops, agricultural enterprises will also expand. This will result in larger commercial plantations that predominantly focus on cash crops for export and are frequently foreign-owned or managed. When compared to family-owned smallholdings, these commercial estates are large. For example, sugar cane plantations can extend tens of thousands of hectares, and other farms (such as cereal plantations) for thousands of hectares. Such plantations are worth millions of dollars, but their products and turnover are at risk from weather and natural disasters. The challenge and potential opportunity here is for NHMSs to: i) develop relationships with the plantation owners to identify opportunities for tailored climate and weather information products; and ii) encourage arrangements where private agricultural enterprises – which host their own AWS infrastructure – share their data with the NHMS.

There may also be opportunities for the NHMS to develop business cases for the installation and maintenance of AWS equipment on private commercial plantations. Preferably, this would happen *en masse* at a national scale, where the volumes make it worthwhile for the NHMS to participate. Business cases between NHMSs and the commercial plantations potentially benefits both parties since a business case could: i) raise revenue for the NHMS; ii) facilitate data sharing from all private sources of weather data, to the NHMS, which when standardised and/or corrected for error, would add value to the national climate record; and iii) develop and retain skills in-country for calibration and maintenance of AWS (synoptic and non-synoptic equipment), which is presently a significant challenge across all countries supported by the CIRDA programme. Given that large commercial estates are often foreign-owned in Africa, these enterprises are likely to be amongst the first to bypass the NHMS and procure tailored climate and weather information from private (international) providers. Consequently, an effective strategy for the NHMS would be to develop long-term commercial relationships with such estates to promote the use of NHMS-generated products and services. In addition, foreign ownership suggests that many agriculture assets might be held across a variety of countries. CIRDA could therefore act as an intermediate on behalf of all the national offices with a carefully selected group of agri-businesses, to secure rights and opportunities on-the-ground for the relevant NHMS.

An essential part of the iterative process of developing, testing, and commercialising dissemination of climate and weather information is the partnering of NHMS with intermediaries – private sector or NGOs – that have existing, trusted interfaces with consumers (further discussed in chapter 9 of this market assessment). This is particularly important for the agricultural sector, since the consumers of climate and weather information (including early warnings) will number tens of millions of individuals across the countries supported by the CIRDA programme. Numerous suitable partnership models and examples of

[73] FAO and UNEP. 2014. Overview of regional fisheries bodies off the Atlantic coast of Africa.
[74] FAO. 2010. FAO Regional Strategic Framework for Africa.

participatory product development processes can be found throughout Africa, such as the regional GFCS programme in Tanzania being led by WMO, with multi-agency partners CGIAR CCAFS, CICERO, IFRC, WFP, WHO, and the Tanzania Meteorological Agency.

Since African women constitute ~70% of the agricultural workforce, their participation in and empowerment through agricultural development have important additional benefits to society other than increased food production and security[75]. Consequently, within the context of the dissemination of tailored climate and weather information, products have to consider gender (including gender-based literacy). Gender-based distinctions in what specific farming activities are undertaken are subtle. For example, studies from West Africa show important distinctions by crop and resource type. Thus, climate and weather products tailored for agriculture need careful consideration of the specific needs of their target market.

**Insurance and microfinance**

Weather Index-based Insurance

Weather Index-based Insurance (WIBI) requires climate and weather information and is therefore often cited as an opportunity within the agriculture and finance market for NHMSs to provide tailored products. However, in contrast to the aforementioned sectors, to date, several pilot projects and work on WIBI have revealed that this opportunity is relatively limited because: i) without strong public sector long-term subsidy, WIBI is ostensibly unsustainable; and ii) after 11 years of activity in the field, the WIBI specialist, MicroEnsure, has withdrawn from all WIBI contracts in Zambia, Malawi and Tanzania.

In spite of these limitations, it is important to note that some WIBI initiatives (such as Kilimo Salama) are still ongoing, and new WIBI initiatives — such as the EcoFarmer project — are now underway. EcoFarmer is hosted by EcoNet in Zimbabwe, with support from Mercy Corps' AgriFin Mobile Programme. A similar initiative is also underway in Uganda with Tigo Uganda. Other prominent insurers, such as the South African-based Sanlam Group (via subsidiary SANTAM) have also expressed interest in entering the agricultural insurance market in East Africa (Kenya and Tanzania in particular)[76]. In addition, Old Mutual plc, which has a large African footprint in the life assurance business, and which has recently acquired UAP Insurance (owner of Kilimo Salama), is now interested in WIBI opportunities in southern Africa via its participation in the global partnership Blue Marble Microinsurance[77]. Thus, while there is still uncertainty over the future of WIBI, other agricultural insurance and micro-finance opportunities – that also require tailored climate and weather information – are emerging in Africa. Once systems are in place, the WIBI market could be a complex but potentially profitable market for NHMSs and commercial partners to engage in.

[75] NEPAD. 2013. Agriculture in Africa: transformation and outlook.
[76] Personal communication with Mr Johan van der Sandt, SANLAM, October 2015
[77] Personal communication with Mr Soshan Soobramoney, Old Mutual Group, October 2015

Microfinance

Microfinance is the provision of a variety of financial services to low-income households and micro/small enterprises that have limited access to banking and related services. These financial services include the provision of micro-loans. There have been interesting advances in the provision of micro-loans in the past decade, with loans being granted to small-scale farmers that are based on innovative models that link soil conservation and landscape management to the performance of the micro-loan facility. NHMSs should monitor the development of these types of models, since there may be potential in the future to provide the microfinance providers with tailored climate and weather products that assist in understanding: i) the underlying risk of their contracts, and ii) client performance.

**Mobile phone platforms**

Mobile phones are increasingly used to disseminate specialised content and information. Even in the most remote locations in Africa, there is often a cell phone tower enabling some communication service. Many NHMSs have recognised this and, along with private weather companies, are collaborating with mobile telephone operators (MTOs) to use these networks to provide early warnings on weather hazards and important agriculture-related (and other) content to the population.

There are two aspects of mobile telephony that are important to consider for early warnings and agriculture-related content. These include: i) potential risk and hazard to mobile infrastructure from hazardous weather; and ii) access to network customers to provide climate and weather information over MTO networks.

Modern mobile networks are, compared to legacy copper cable networks, reasonably robust. Masts are however still susceptible to damage from storm winds and lightning, and need to be constantly powered. Given Africa's great size, poor infrastructure, and weak power grids, the installation of mobile masts are such a specialised undertaking that it is often managed by a dedicated business, which leases the mast's bandwidth to subscribing MTOs. These mast operators – such as IHS, which is dominant across West Africa – are possible consumers of early warnings and tailored weather products.

CIRDA is aware of the potential for climate and weather information to be served over MTO networks, having engaged extensively with the pull service from Human Networks International, 3-2-1. This service is hosted on the Madagascar, Malawi and Uganda Airtel networks, with discussions underway in a number of other African countries to expand the service. The 3-2-1 service is mature, has a proven business case, and provides a range of specialised content, including weather information. While 3-2-1 (and similar services) will not pay for basic climate and weather information, there are possibilities for opt-in, or subscription based, value-added services like that which EcoFarmer (Zimbabwe) offers to its premium customers. Similarly, Vodafone developed the Connected Farmer Alliance (CFA) platform to enable farmers to access information on weather and crop prices via their mobile phones. The CFA is a public-private partnership that promotes commercially sustainable mobile solutions to increase agricultural productivity and revenues for 500,000 smallholder farmers across Kenya, Tanzania and Mozambique[78].

Push services are preferable for early warnings, since they do not rely on users to instantiate the connection. However, these are more expensive and to meet standards of accuracy and trustworthiness, the provider needs to have reasonably accurate knowledge of the location of the user. This is because in areas with diverse topography the weather conditions of two locations ~50 km apart can be considerably different. However, this information is often problematic to acquire. To address this problem and provide effective early warnings, SANTAM (the South African short-term insurer), in conjunction with SA National Disaster Management Centre and the South African Weather Service, directs SMS alerts to those customers that have assets sensitive to hail (for example, motor vehicles), within the high risk zones, within their customer database.

[78] More information available online at: http://www.vodafone.com/content/index/media/vodafone-group-releases/2014/tanzanian-farmers.html.

**Fishing**

Africa generates ~25% of the global fisheries production, with fish contributing to ~20% of people's total animal protein intake in Africa[79]. Fisheries are therefore an important sector is Africa, including the countries supported by the CIRDA programme. However, the fisheries sector is vulnerable to climate change, particularly extreme climate events. Indeed, it is estimated the financial costs to the fishery industry of adverse weather events and the effects of climate change is ~US$311 million annually.

Since weather plays such a pivotal role in the financial stability of the fishery industry, information on weather variables – including *inter alia* rainfall, winds, currents, surface temperature and turbidity – are important for local fishermen. This includes both marine and freshwater fishermen, who each require slightly different types of climate and weather information. The fisheries sector provides a good opportunity for NHMSs to supply early warnings as well as tailored climate and weather products that contribute to increased harvesting of fish.

**Summary**

The climate and weather information needs of all the identified climate-sensitive sectors are summarised in the table below. This information was obtained through interviews with representatives from these sectors as well as formal reports and peer-reviewed articles.

**Table 7.2.** General overview of climate and weather information needs per sector.

| **Sector** | **Climate and weather information needs:** |
|---|---|
| Aviation | • Weather information for take-off and landing.<br>• Aircraft route forecast.<br>• Aerodrome Forecast.<br>• In-flight hazards (e.g. icing, lightning and storm activity, wind shear, etc.). |
| Agriculture | Climate and weather information used for:<br>• irrigation;<br>• crop protection;<br>• crop insurance;<br>• crop management;<br>• early warnings for food security; and<br>• climate risk management. |
| Insurance | • Climate and weather information that is used to model crop production.<br>• Early warnings for extreme climate events. |
| Mobile phone platforms | • Early warnings for extreme climate events. |
| Fishing | • Climate and weather information for fishing strategies.<br>• Early warnings provided over lakes such as Malawi, Tanganyika, Victoria, and for in-shore fisheries (West and East Africa). |
| Water Resources | Climate and weather information used for:<br>• the design of dams, water transport and irrigation schemes; and<br>• early warnings for floods and droughts. |
| Energy | Climate and weather information used for:<br>• hydropower;<br>• wind energy; and<br>• solar energy. |

[79] FAO. 2008. The state of World Fisheries and Aquaculture.

| | |
|---|---|
| Mining | Climate and weather information used for:<br>• road access;<br>• slope stability;<br>• construction of mine infrastructure;<br>• safe working environment; and<br>• dispersion of hazardous gases. |
| Building and Construction | Climate and weather information used for:<br>• road construction; and<br>• building construction. |
| Retail | • Weather information for marketing strategies and in distribution of weather-sensitive items. |
| Legal | • Evidence provided in courts for weather-related cases. |
| Environment | • Climate change information. |
| Road and Railway Transport | • Climate and weather information to inform road or railway line usage. |
| Sport and Recreation | • Forecasts for yachting marathon.<br>• Forecasts for soccer matches. |
| Health | • Climate and weather information for prediction of disease outbreaks and public health planning.<br>• Meteorological information for research. |
| Disaster Preparedness | • Tropical cyclone and tsunami warnings.<br>• Early warnings for drought, flood and wildfire.<br>• Flood forecasts. |
| Banking | • Weather/climate forecasts for agricultural loans. |
| Public | • Short-range weather forecasts.<br>• Medium range weather forecasts.<br>• Seasonal forecasts. |

# 8. THE LAST MILE

## 8.1 Background

Climate-related hazards – such as intense rainfall and heavy storms – are becoming more frequent and severe across Africa. To improve the preparedness of African communities to respond to these climate-related hazards – thereby preventing the loss of lives, infrastructure and livelihoods – it is imperative to communicate accurate, actionable and trustworthy climate and weather information. This is particularly the case for vulnerable communities located in remote areas, as access to transport and communication infrastructure is limited.

Raw weather data are of little value to local communities, since they do not provide an actionable warning instruction or prediction. In addition, the information derived from these data – such as a seasonal climate outlook – may not be in the appropriate format or language for local communities to use and understand. This information, however, is necessary for a farmer to make informed decisions on which crops to plant or to take precautions against specific hazards – for example, heavy rain or hail. The process of using data to develop an actionable instruction is required for both climate and weather information.

Disseminating information from the producer to the end user in a timeous, reliable and understandable manner is referred to as the "Last Mile" of the communication process. This term is often used in the telecommunications and technology industries. For example, the Last Mile is used to describe the technologies and processes implemented to connect the end user to a communications network. The “Last Mile” is also often stated as the "Last Mile problem", because “the end link between consumers and connectivity has proved to be disproportionately expensive and difficult to solve.” [80] Within the CIRDA programme, the “Last Mile problem” refers to the challenges related to disseminating timeous and appropriate climate and weather information from the NHMS to the end users, particularly local communities and smallholder farmers.

This chapter provides an overview of the Last Mile challenges and explores barriers, opportunities, and successes in overcoming these challenges. Since the Last Mile challenge is not unique to climate services, the lessons learned from other organisations in the private as well as the public sector were also considered.

## 8.2 The Last Mile

The Last Mile challenge is a common distribution problem that is pervasive across a range of private and public sectors. Examples of these include telecommunications and traditional retail distribution, as well as public transport, primary health care and electricity distribution. Within all of these sectors, the infrastructure required to cross the Last Mile – both physical and logistical – is costly to install and maintain. As a result, the Last Mile remains a challenge even in developed economies.

Access to weather information can reduce the damage of climate-related hazards by providing a direct message for action to the population – for example, through early warning alerts. However, many climate-related messages – including predictions or outlooks – are complex and require a trusted intermediary to assist with interpretation to act accordingly. To achieve the required action based on the information provided, building the trust of consumers in the climate services information is essential. Each messaging strategy therefore requires the participation of all stakeholders in developing and testing the message. These stakeholders include the: i) producers of weather information – for example the NHMS; ii) communicators and boundary organisations[81] – for example media, agricultural extension teams, NGOs, CBOs and the private sector; iii) national-level end users of weather information – for example agri-

[80] http://www.investopedia.com/terms/l/lastmile.asp#ixzz3uyC2w4PS. Accessed on 21 December 2015.
[81] These are called boundary organisations as these operate on the boundary between the NHMSs and local communities. These organisations facilitate the dissemination of information.

businesses and policy makers; and iv) community-level end users – for example smallholder farmers and pastoralists[82].

The NHMSs in the countries supported by the CIRDA programme currently deploy their limited financial, human and technical resources to: i) develop and disseminate weather alerts; and ii) produce basic national forecast products. To improve these services, some instructive pilot projects have taken place across the 11 countries supported by the CIRDA programme (see Chapter 3). However, most NHMSs in these countries do not presently have the technical capacity required to provide farmers and citizens with climate services that meet their diverse needs.

These resource and capacity limitations reduce the quantity and quality of weather data, particularly as a result of *inter alia*: i) insufficient and ineffective equipment; ii) limited understanding of the consumers and their needs; iii) inadequate interpretation of weather data to produce information that is relevant to the needs of the consumer; and iv) insufficient human resources and capacity to package the information into a tailored product (see Chapter 5 for more detail). Consequently, climate and weather information often does not reach the intended local community stakeholders – for example smallholder farmers – timeously and/or in the right format or scale. In addition, national climate and weather information is often of lower quality than products typically required by private sector consumers – for example aviation.

The effective dissemination and uptake of weather information by local communities or end users is prevented by multiple barriers including: i) restricted knowledge of agricultural practices; ii) inadequate market information; and iii) limited capacity of boundary organisations to access local populations[83]. Additional challenges to disseminating weather information to the Last Mile include: i) directing the message via appropriate media in a sustainable, cost-effective and credible manner; ii) distinguishing audience needs, for example gender and language considerations; iii) developing information that is appropriate at local scales; and iv) overcoming distrust and the negative sentiment often attached to information received from the NHMS. Refining and extending existing products – or developing new ones – will therefore require new methods and approaches given the various limitations that dominate the operating environment.

As discussed above, Last Mile challenges include disseminating standardised short-term (< 2 weeks) weather information or emergency weather alerts, and long-term climate-related messages. Most of the discussion below is focused on this short-term information.

## 8.3 Pathways to cross the Last Mile

The following considerations need to be incorporated into strategies for developing and disseminating climate services to the Last Mile:

- studying the local context and considering cultural norms, including gender-based preferences and needs;
- engaging regularly with end users, preferably face-to-face, and using trusted intermediaries who understand the local context to either deliver or support the services provided by the NHMSs;
- building on existing networks and infrastructure wherever possible;
- accessing public funds to experiment with and pilot different pathways, since successful Last Mile models tend to be complex;
- engaging with the private sector from the outset as sustaining these pathways requires partnerships;
- bundling climate services with other trusted products and services including loans, insurance, market information and agri-extension;
- being prepared to follow adaptive and iterative learning cycles; and

[82] Tall, A. et al. 2014. Scaling up climate services for farmers: Mission possible.
[83] https://gsmaintelligence.com/research/?file=127f3a0df49cab82194d0df966f503bc&download. Accessed 11 December 2015.

- seeking out virtuous cycles that *inter alia* focus on value, promote trust with the end user and favour models that improve access to climate services.

Several communication channels exist that can be used to address these barriers. In the past, weather information was primarily disseminated to the end user through traditional channels, including: i) media (television, radio and print); ii) retail distribution – for example, supermarkets; and iii) face-to-face meetings – for example, through church groups, extension workers and fellow farmers. Traditional communication can be effective since local communities know and trust these channels[84]. However, these traditional channels are restricted in a number of ways. As a result, non-traditional channels of communication – including mobile phones (SMS and voice messages) and social media (for example WhatsApp, Twitter and Facebook) – are increasingly being used to disseminate weather information.

Mobile phone technology in particular is widely considered to be an effective tool for crossing the Last Mile. This technology has been used extensively in recent projects that focus on disseminating climate and weather information. However, mobile phones are not a panacea for addressing the Last Mile problem, as this technology presents its own challenges, including limited: i) coverage of mobile networks; ii) contract subscription in the African market; iii) demand for – and hence penetration by – smartphones; iv) payment for network traffic; v) literacy in rural Africa – especially amongst women – which reduces the uptake of climate-related information in important sections of the target market[85]; vi) experience among end users in using mobile phones for climate-related applications; and vii) overall affordability of technology, which impacts on building scalable and sustainable business models.

## 8.4 Examples of existing efforts and opportunities for African climate services to cross the Last Mile

Despite the challenges associated with mobile phones, this technology has created new opportunities for crossing the Last Mile, particularly in Africa. In the past 10 years, Africa has become the world's fastest growing mobile market, with subscriber growth rates more than twice the global average[86]. Of the 1.13 billion Africans, ~67% own mobile phones[87]. This is expected to increase to ~80% by 2020[88]. With this rapid rate of absorption, efforts are being made to develop sustainable models that allow diverse content to be distributed by mobile phones. These models typically entail partnerships between private sector telecoms operators and NGOs. Most efforts therefore involve in-country participation or leadership from private sector mobile phone operators, with international NGOs or multi-lateral support (often funding).

While non-mobile internet penetration in Africa remains limited at ~20%[89], mobile internet penetration into Africa is increasing[90]. And decreasing device prices are promoting the rapid adoption of smartphones, with the continent likely to add more than 400 million new smartphone connections by 2020 – by which time there will be over half a billion people in Africa using smartphones[91].

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[84] CCAFS Report No. 13. Scaling up climate services for farmers: Mission Impossible.
[85] Source: UNESCO Institute for Statistics, May 2013
[86] https://gsmaintelligence.com/research/?file=721eb3d4b80a36451202d0473b3c4a63&download Accessed on 20 December 2015.
[87] http://www.ngrguardiannews.com/2015/06/africas-mobile-phone-penetration-now-67/ Accessed on 20 December 2015.
[88] Frost and Sullivan, 2015. Available online at: http://ww2.frost.com/news/press-releases/sub-saharan-africa-witness-fastest-growth-mobile-usage-rates-globally-finds-frost-sullivan/. Accessed on December 17 2015.
[89] Source: ITU World Telecommunication. Estimates for 2014
[90] Only ~5% of the market operates on a subscription or contract basis, although this is expected to increase by ~50% over the next two years. Additionally, GSM-/EDGE-only subscriptions are expected to remain dominant up to 2020 as a result of lower income consumers preferring cheaper, 2G-enabled handsets. Reliable data services (required by smartphones) are still limited in Africa owing to the comparatively less developed network infrastructure. https://gsmaintelligence.com/research/?file=721eb3d4b80a36451202d0473b3c4a63&download. Accessed on 22 December 2015.
[91] https://gsmaintelligence.com/research/?file=721eb3d4b80a36451202d0473b3c4a63&download. Accessed on 22 December 2015.

### 8.4.1 Human Network International's 3-2-1 service

To date, solutions that use voice services, SMS texting, and Unstructured Supplementary Services Data (USSD) are the preferred method for communicating critical information to African populations. The use of voice messaging is particularly promising since such information can reach populations with low levels of literacy.

In recognition of this preference for voice messaging, the NGO Human Network International (HNI) has developed a service that provides the public with diverse and useful information. This information is disseminated using voice recordings available on demand (i.e. push) by mobile phone users who dial in, toll-free. This service, called "3-2-1", is available in Malawi and Madagascar vial local telephone companies and is offered at no cost to Airtel users. Other network users can access the service but have to pay for the connection[92]. Human Network International was recently approached by Airtel in Uganda to expand this service to its Ugandan users, with further expansion into as many as nine other African countries presently under consideration[93]. Since the 3-2-1 service is not partnered with one specific platform, it is likely that this expansion will include partnerships with other network operators *viz*. Orange, Vodacom, Tigo and MTN.

The 3-2-1 model provides well-organised, carefully framed, customised content with up to 400 messages across eight topics and 40 sub-topics. Weather information is only one of these sub-topics. Headline topics include gender, health, agriculture, micro-finance, water and sanitation, land tenure, family planning, and emergency preparedness. The model has undergone extensive testing and development over 10 years in the Madagascan market and can therefore be considered mature.

While this partnership between an NGO and the private sector is mutually beneficial, the NHMSs are constrained since HNI offers the content for free, provided Airtel does the same. This means HNI will not pay for any climate or weather information, since they make use of publically available information. However, users can register for (i.e. 'pull') value-added services on the 3-2-1 service. Consequently, there may be alternative channels to market and distribute tailored weather information.

The 3-2-1 model is sustainable because of the capacity of Airtel to subsidise millions of calls ("30+ years of airtime"[94]). Their analysis indicates that through offering 3-2-1 as a value added service on its network, Airtel will: i) attract new customers; ii) encourage use of other advanced telephony services (~9–28% increase): iii) promote subscriber loyalty (reducing consumer loss by ~15%); iv) educate new users; and v) achieve corporate social responsibility goals. In Malawi alone, over 600,000 unique users accessed the service within the first three months of rollout[95]. HNI continues to source and package appropriate content with experts, content providers and owners to make 3-2-1 more attractive to end users in a competitive telecom market.

### 8.4.2 Mercy Corps' Agri-Fin Mobile programme

The Agri-Fin Mobile programme of Mercy Corps – a US-based but globally active NGO – seeks to improve the access of smallholder farmers to critical information with mobile phone technology. This, it is believed, will improve the management of agricultural production cycles. By partnering with existing mobile platforms that have developed financial and agricultural technical services, Agri-Fin bundles essential agricultural information – including weather information, farm and crop management tools, as well as financial services such as mobile payments – on affordable, unified mobile platforms that promote mass uptake[96].

A main feature of the programme is its focus on partnering with established in-country mobile operators. In Uganda the MTO is Tigo and in Zimbabwe, EcoNet. The EcoNet-branded service is known as "EcoFarmer" and exists alongside other EcoNet services such as EcoCash, EcoSchool, and EcoHealth. Since the launch of

[92] http://hni.org/what-we-do/3-2-1-service/. Accessed on 10 December 2015.
[93] Personal communication with Mr D. McAfee, HNI on 1 October 2015.
[94] Personal communication with Mr D. McAfee, HNI on 1 October 2015.
[95] http://www.undp-alm.org/sites/default/files/downloads/14._3-2-1_service_feb_2015.pdf. Accessed on 10 December 2015.
[96] https://www.mercycorps.org/research-resources/agri-fin-mobile. Accessed on 14 December 2015

EcoFarmer in October 2013, over 200,000 clients have opted into the EcoFarmer platform and almost 30,000 farmers have been profiled to receive daily farming tips, weather updates and market prices. Additionally, 1,100 farmers were covered by the weather index insurance in the 2013/2014 agricultural season[97]. The service available to an EcoFarmer can be used in one of two ways: i) free service – excluding the cost of the mobile charges – when limited, basic information is received; or ii) subscription or purchase of an agri-insurance product. These clients receive a premium access model that includes additional information, such as daily market prices and more detailed forecasts.

The pilot phase was initially established in one province, and demonstrated that the model has a positive impact on access to relevant services, assisting farming and improving potential income for the users. Smallholder farmers reported value in accessing the information and market services, and showed improved farming techniques. There were, however, challenges with network connectivity, delivery mechanisms and payment methods that deterred uptake. Nonetheless, the EcoFarmer pilot was extended into a second province (Mashonaland Central) in July 2014[98].

Another challenge with implementing the programme was that farmers had limited willingness to trust and act on the information that they received. This resulted from the lack of face-to-face interaction with a trusted intermediary, unlike traditional channels of distribution. A survey conducted in August 2012 as part of the Agri-Fin Mobile programme demonstrated that radio and face-to-face consultations were preferred sources of information for farmers. Similarly, a CICERO study conducted in Tanzania revealed that traditional channels and sources of knowledge are still preferred over digital forms.

Agri-Fin has overcome this challenge by partnering with established and trusted brands such as EcoNet and Tigo. In addition, Agri-Fin enters a new market by holding community meetings and involving agricultural extension services[99]. Currently, this hybrid model is considered to be the best practice and should therefore inform any similar efforts undertaken by NHMSs for delivering climate services information. According to AgriFin: "*the programme from inception has utilized the inclusive development approach by engaging relevant stakeholders at community, regional and national levels. Partnerships were formed at various levels and local resources and gatekeepers at community levels were included in all stages of development. An inclusive approach is therefore key for uptake as multiple stakeholders can push for adoption and use of the product from various angles and can contribute to reaching scale.*"[100]

Similar experiences that demonstrate the value of a hybrid model that uses existing channels and traditional intermediaries are evident in a WMO GFCS project in Tanzania "Malawi and Tanzania: Climate Services Adaptation Programme in Africa – Building Resilience in Disaster Risk Management, Food Security and Health (2013–2016)"[101]. This programme – funded by the Government of Norway – aims to increase the resilience of people most vulnerable to the impacts of climate and weather-related hazards. These hazards include droughts and flooding and associated health risks, such as malnutrition, cholera and malaria. In addition, combining science with traditional knowledge will strengthen the capacity of these countries to develop and use climate services.

### *8.4.3 Kilimo Salma Weather Index-Based insurance*

Kilimo Salama is a Kenyan weather index-based insurance product that provides cover for farmers' inputs in the event of drought or excessive rainfall. This initiative was developed by the Syngenta Foundation for Sustainable Agriculture (SFSA) and launched in partnership with Safaricom – the largest mobile network operator in Kenya – and UAP, a large insurance company based in Kenya[102].

[97] http://www.agrifinmobile.org/?q=node/93#sthash.IUIvAdxy.dpuf. Accessed on 14 December 2015.
[98] http://www.agrifinmobile.org/?q=node/93. Accessed on 10 December 2015.
[99] Personal conversation with Mildred Makore.
[100] http://www.agrifinmobile.org/?q=node/93. Accessed on 17 December 2014
[101] Personal conversation with Sofie Sandström.
[102] https://kilimosalama.wordpress.com/about/ Accessed on 17 December 2015.

Kilimo Salama is an insurance product that reduces the loss of income that farmers experience as a result of rainfall variability. Pay-outs are based on comparisons between current and historical rainfall patterns for the region. During the planting season, actual rainfall is measured using local, solar-powered weather stations that collect weather data every 15 minutes. At the end of each growing season, the collected data are compared to historical weather data and any pay-out owed is calculated and credited to the farmer through mobile banking. Kilimo Salama is the first micro-insurance product in the world to be distributed and implemented through a mobile phone network. The product is considered a successful initiative because of the factors described below.

Mobile phones

Conducting most transactions – including banking over mobile phones – is the main reason for this product's success. Mobile phones provide a cheap distribution mechanism for the insurer and are easily accessible for the customer.

For example, in 2010, the Syngenta Foundation – on behalf of Kilimo Salama – partnered with telecom operator Safaricom, which provided an affordable and dense communications network for product sales and customer communication. Through Safaricom's M-PESA mobile banking system, insurance premiums became accessible for smallholder farmers since many have mobile phones. In addition, it became economically viable for insurance companies to reach these farmers since the mobile platform is more cost-effective than traditional (e.g. face-to-face) approaches. Farmers receive their insurance policy numbers and premium receipts via SMS, and pay-outs are similarly sent electronically via M-PESA. The product is also scalable for the insurance company since the marginal cost of an additional customer is minimal.

Pay-as-you-plant

The "pay-as-you-plant" type of insurance in Kilimo Salama allowed farmers to test an insurance product which is unfamiliar in Kenya. As farmers learned to trust insurance, they expanded their insurance coverage and became comfortable with increasing investments in their farms, thereby raising their productivity and increasing their food security. In short: this initiative developed a product that enabled farmers to test insurance and experience its benefits.

Use of local trainers and intermediaries

An additional challenge facing Kilimo Salama was educating potential customers on the benefits of insurance. Overcoming this challenge required establishing trust with the customer. This was achieved by offering the product via a supplies stockist with whom the farmers had an already established relationships. In addition, using local trainers increased farmers' trust in the insurance product. Kilimo Salama also has a phone help line that farmers can use to ask questions about the product. This line is open to both existing and potential customers. The project was sensitive to cultural differences for each region in setting up the help line. For example, call centre agents for the help line were trained on how to engage with customers from different regions, such as being taught the proper greeting for each region.

Kilimo Salama has recently expanded the programme to Rwanda, with plans to expand to other countries in eastern and southern Africa. At the end of 2013, ~185,000 smallholder farmers in Kenya and Rwanda had obtained Kilimo Salama insurance. Most of these insurers were farmers taking loans from MFIs to buy certified seeds and fertiliser, where the insurance was mandatory and bundled into the loan. According to Syngenta, a 2012 impact assessment concluded that insured farmers invested ~20% more and earned 16% more than their uninsured neighbours[103].

[103] http://www.syngentafoundation.org/__temp/Kilimo_Salama_3_Pager_21_1_14.pdf. Accessed 17 December 2015.

### 8.4.4 Improving the delivery of weather information services to the Last Mile

The following factors improve delivery of mobile information services and are worth considering in delivering tailored weather services across the Last Mile.

Involving a strong "jockey" or product champion is critical

The success stories described above demonstrate commitment from senior management of the relevant organisations – including mobile operators, NHMSs and agricultural extension services – who see the long-term value from leveraging their network in this way.

Determine gaps in services that inhibit demand

Some farmers resist new financial or information services as they require behavioural change – for example inserting a new SIM card. Therefore, to promote uptake, initiatives that use mobile platforms should operate within a framework in which farmers are comfortable. This requires information on mobile infrastructure and service usage by farmers to tailor product development and service delivery. Possible solutions include: i) establishing models similar to the 3-2-1 initiative, where the business case for the mobile host enables the service to be freely accessible (i.e. no charge for the calls); ii) developing mobile network operator platforms that farmers can access irrespective of the network they use, precluding their opting out of existing plans; and iii) recognising that farmers' continued usage depends on offering value for their money (for premium services) through a suitable billing plan and ensuring clear understanding of the actual cost of such plans – for example by declaring transaction fees or kick-in membership dues.

Tap existing channels to farmers

"Piggybacking" off existing trusted and appropriate channels accessed by farmers can improve the dissemination of weather information, and enhance the use of this information. Channels to farmers are diverse but can include: i) co-operatives and agricultural extension service providers – who have direct contact with farmers and can provide support and immediate technical advice; ii) traditional retail outlets; and iii) lead farmers and community leaders who are trusted by local communities and can therefore encourage support for new information technologies.

Look ahead and be patient

Making information "mobile" can increase outreach to smallholder farmers and assist in connecting them with market players and financial services providers directly – and at relatively little cost. However, the potential of mobile information services far exceeds farmers' current demand for it. Lessons from WIBI indicates that the success of novel financial services – such as insurance – requires a long period of direct intermediation[104]. Therefore, Airtel's long-term commitment to 3-2-1 and its support for an ongoing dialogue between the consumer and mobile service providers / content providers contributes to its success. This demonstrates that building lasting value and trust needs around 10 years, which ultimately results in rewards for consumers, content providers, and intermediaries such as the MTOs.

## 8.5 Lessons learned from Last Mile 'Bright Lights' in other sectors

The Last Mile has been successfully reached in other sectors. In particular, the retail sector has been effective in disseminating products to rural communities. These 'Bright Lights' are discussed in detail below.

### 8.5.1 Coca-Cola

[104] Personal conversation with Mr D. Dorey, MicroEnsure on 16 October 2015.

Coca-Cola serves ~1.5 billion customers every day. With a global population of ~7 billion people, this equates to every man, woman and child on the planet having a serving of coke every week. Coca-Cola's Last Mile success can be attributed to three factors:

1. Using **real time data** to measure trends in demand. There is also a feedback loop that has been developed to adjust the product according to emerging trends.

2. Tapping into **local entrepreneurial talent**. Coca-Cola has been in Africa since 1928, but could not until 1990 distribute its products in an organised way to remote areas as a result of poor road infrastructure. In the 1980s Coca-Cola observed a trend wherein local entrepreneurs were purchasing the product in bulk and reselling it in rural areas where Coca-Cola's distributing trucks could not reach. In 1990, Coca-Cola began training these local entrepreneurs and distributing small loans to set up micro-distribution centres. Subsequently, those local entrepreneurs hired sales people to go out into villages and other remote areas with bicycles, push carts and wheelbarrows to sell the product. Currently, there are ~3,000 of these micro-distribution centres, employing ~15,000 people across Africa. In Tanzania and Uganda, this form of distribution accounts for ~90% of Coca-Cola's sales.

3. **Marketing.** Coca-Cola's success is largely attributed to their marketing. In the context of this study, marketing supports the product by building awareness and familiarity with the brand and its products. Lessons for CIRDA include *inter alia* Coca Cola's willingness to modify their global marketing message – "Open Happiness" – and tailor it to the local context. Coca-Cola achieved this modification by undertaking detailed on-the-ground research on what the message means within a given area. For example, Coca-Cola found that in Latin America happiness is associated with family life whereas in South Africa it is associated with community respect.

Coca-Cola's success at crossing the Last Mile has resulted in a public-private partnership between Project Last Mile and Coca-Cola. Since its launch in 2010, Project Last Mile has been using Coca-Cola's supply chain, distribution and marketing expertise to help African governments get vital medicines and supplies to some of the hardest-to-reach parts of the continent. The project was originally implemented in Tanzania and Ghana, and has subsequently announced plans to expand to ten countries over the course of five years.[105]

### *8.5.2 South African Breweries (SAB)*

SAB-Miller has operations in 15 African countries and a stake in 21 others. SAB became popular across Africa in the mid-1990s when it brought newly-privatised breweries into Mozambique, Ghana, Uganda, Zambia and Tanzania.

Until 1962, black South Africans were prohibited from purchasing commercially-brewed beer. Consequently, South African beer distribution initially depended on shebeens that offered their own brews. When the prohibition lifted, SAB used shebeens and other small outlets to promote its business, selling almost all the beer through these outlets. To achieve this, SAB developed a network of drivers who could deliver products along rough and poorly developed rural roads. In addition – using an "owner-driven" model – SAB established former employees with their own trucking business. The company also ensured that each of its rural distributors had refrigerators and generators.

SAB has also achieved Last Mile success through buying local brands that are known and trusted by local communities, rather than exporting one homogenous brand world-wide. The company has customised their products to the local context, thereby facilitating local acceptance and uptake.

## 8.6 Last Mile concluding comments

Addressing the Last Mile challenge is a complicated endeavour that requires consideration of the local context and the relationships between the stakeholders. However, many lessons can be learned from pilot

[105] http://www.coca-colacompany.com/our-company/infographic-project-last-mile/. Accessed on 17 December 2015.

projects and related experiences in other sectors. For example, a strong in-country mobile operator is necessary, but not sufficient on its own, for meeting the challenge. Fundamental to the success of bridging the Last Mile is: i) understanding the target market and needs of the target group; and ii) identifying appropriate channels to support digital and/or traditional delivery of weather information. In addition, face-to-face intermediation is still required in the early stages of adoption. If content and information are carefully packaged to accommodate local preferences and needs, trust will be fostered and the assimilation of services and products into local communities will ultimately be enhanced.

# 9. PATHWAYS TO COMMERCIALISATION OF CLIMATE SERVICES

In the 11 countries supported by the CIRDA programme, the NHMSs are facing several challenges to effective provision of climate services. This is a result of their limited technical and financial capacity to maintain and improve the basic infrastructure required for efficient service provision. To date, there has been limited investment into strengthening the technical capacities of the NHMSs, which is compounded by a general disregard for the social and economic benefits provided by improved climate services. The inadequate enabling environment within many of these countries further limits funding of the NHMSs as there are often no provisions to support revenue generation for the cost-recovery of their services[106].

A proactive approach to improve their income stream is increasingly common among the NHMSs within Africa – an approach that would ultimately lead to the transformation of NHMSs from government agencies to autonomous or semi-autonomous entities. This transformation would be advantageous to both the government and NHMSs since governments would be relieved of the responsibility of being the sole resource provider, while NHMSs would be empowered to engage with the private sector and charge for their products and services. Examples of NHMSs that have adopted autonomous or semi-autonomous status in Africa include *inter alia* those in Tanzania, South Africa, Nigeria, Ghana, Zimbabwe, Ethiopia, Morocco and Egypt. Among the countries supported by the CIRDA programme, The Gambia, Burkina Faso, Liberia and Zambia have each submitted a draft act to their national government proposing that their NHMSs become autonomous or semi-autonomous entities, thereby establishing the legal framework for NHMSs to charge for their products and services[107,108]. However, a transformation to a (semi-) autonomous entity may be challenging, as it is likely to require fundamental changes in the structure, resourcing and behaviour of the NHMS. To address these challenges and support this process of transformation, the WMO has suggested that its representatives monitor this process and examine the potential benefits of converting to a (semi-)autonomous entity model. In particular, the WMO has suggested that African weather agencies that are already autonomous – such as those in Tanzania and Uganda – be reviewed and assessed to learn lessons from their transformation.

It is furthermore unlikely that substantial revenue streams will be generated for the NHMSs by the sale of data *per se*. Rather, the market opportunities for NHMSs mainly lie in taking shares in future revenues generated through down-the-line sales of tailored climate and weather information products developed in partnership with selected private weather companies. Forging such revenue-sharing partnerships will require *inter alia*: i) in-depth and lengthy negotiations with the private sector; ii) the establishment of appropriate institutional structures; iii) considerable knowledge on doing business within the climate and weather market; and iv) an enabling policy and legal environment. Importantly, the negotiations with the private sector will need to be underpinned by detailed information on the local market for each country supported by the CIRDA programme.

## 9.1 Regulatory frameworks and use of policy and regulations

In a 2015 report, the WMO highlighted the different and complementary roles and responsibilities of NHMSs, research institutions and the private sector[109]. To avoid competition and overlap in roles and mandates, the WMO advocates for the development of regulations and service-level agreements between the private sector and NHMSs. These regulations and agreements would contribute towards improving the accuracy, accountability and quality in the delivery of climate services to end users. Mutually beneficial partnerships between NHMSs and the private sector that stimulate innovation and facilitate cross-fertilisation have been demonstrated in pilot projects of the WMO such as those within the GFCS. Moreover, the WMO lists open data policies and their potential impact on stakeholders[110] as one of the future challenges and opportunities for the NHMSs to engage with the private sector. However, both of these cases necessitate a strong framework to regulate – and facilitate – the interface between the NHMSs and the private sector.

[106] East African Community: Five-year meteorological development plan and investment strategy, 2004.
[107] Personal conservation with NHMS representatives at CIRDA workshop in Addis Ababa on 27 August 2015.
[108] The Department of Meteorology in Liberia aims to follow the same route as the Department of Disaster Risk.
[109] World Meteorological Organisation. 2015. Valuing Climate and weather: Economic Assessment of Meteorological and Hydrological Services. World Meteorological Organisation, Geneva.
[110] This document was discussed and presented at the 17th World Meteorological Congress from 25 May–12 June 2015 in Geneva.

Regulatory frameworks governing the provision of climate services should highlight the potential value of the NHMS to public safety. For example, such a framework should define how warnings are disseminated by the NHMSs and used by the general public. In doing so, the regulatory framework would facilitate: i) improved preparedness for disasters; ii) prevention and reduction of economic losses; and iii) protection of lives and property. In addition, a clear legal and regulatory framework will enhance the understanding of stakeholders – including government authorities and media – on their respective responsibilities as well as appropriate actions to be taken when weather-related warnings are disseminated by the NHMS[111]. Although it is difficult to make legal provisions regulating the communication channels used by the NHMS to disseminate these weather-related warnings, NHMSs are required by the WMO to use the most appropriate channels to reach as many citizens as possible. For example, mobile networks have been shown to be an effective channel for this mass dissemination of weather information. Partnerships with mobile phone companies can therefore play a pivotal role in providing end users with weather-related warnings in remote areas.

In the absence of a framework regulating dissemination of information and warnings, other entities could provide warnings to end users that might be in conflict with the warnings that are produced by the NHMS. In the event of extreme weather, this could place public safety in jeopardy owing to confusion over what precautions should be taken to reduce the risk of losses to lives and infrastructure. To prevent such confusion and its potentially catastrophic consequences, regulators of weather information should consider the pitfalls that may compromise the abilities of private entities to provide quality climate services, such as the: i) absence of formulated plans to prevent meteorological disasters; ii) failure to take measures to prevent disasters and timely emergency responses; iii) description of weather stations as compliant even though they may not align with international frameworks; and iv) non-dissemination of warnings or the provision of false warnings.

In addition to promoting accurate and reliable weather-related warnings, a country's regulatory framework can direct the provision of funds from national treasuries to the NHMSs. To promote this funding, business plans that show the value provided by investing in the NHMS and the returns on these investments to society, need to be developed. In addition to support from national treasuries, funding to NHMSs can be provided through engagement with the private sector, but this would again require a favourable regulatory framework. Bilateral and multilateral institutions could also be potential financial supporters of the NHMSs for improving their observation networks and strengthening their service delivery. Through economic assessments and other analytical work, these institutions can enhance the profile of the NHMS in their respective governments and indirectly support increased government funding.

## 9.2 Public-private partnerships

A public-private partnership (PPP) is a partnering between the public and the private sector for mutual benefit, e.g. establish a new entity or to exchange information. PPPs can often provide more efficient and qualitatively improved services than either of the two separate entities as a result of the combination of public and private resources. In the context of climate services, establishing a PPP can facilitate data exchange between the NHMSs and the private sector, as well as facilitate private sector investment in additional observation stations to strengthen the national observation network[112]. However, an important prerequisite for NHMSs to enter into a PPP is a careful analysis of the advantages and risks of this partnership (see Table 9.1). In addition, a clearly defined legal and regulatory framework is needed to establish PPPs, as described in Chapter 9.1.

**Table 9.1.** Advantages and risks of public-private partnerships (Amended from Lienhard, 2006).

| **Advantages** | **Risks** |
|---|---|
| *For public authorities and state-owned agencies* | |
| • Financial relief or gain in efficiency<br>• Revenue retention | • Selection of partner<br>• Long-term commitment |

[112] Rogers, et al. 2013. Climate and weather Resilience: Effective Preparedness through National Meteorological and Hydrological Services. Directions in Development. Washington, DC: World Bank.

| | |
|---|---|
| • Contracting and procurement flexibility<br>• More rapid realization of projects<br>• Optimised task fulfilment or relief<br>• Image enhancement | • Opportunist behaviour of private enterprises<br>• Conflict of interest or political risks<br>• Limited transparency |
| *For the private partner* | |
| • Opening of new markets<br>• Attractiveness of the public business partner<br>• Improvement in the chances of success<br>• Anticipation of yields | • Long-term commitment and stability<br>• Long path to decision<br>• Pseudo-competition<br>• Diverging interests<br>• Financial risks |

Globally, partnerships to reduce the risk of natural disasters for local communities through the production and dissemination of weather information have predominantly been between NHMSs and NGOs (see Chapters 3 and 4). However, there are several examples across the world – including in Africa – where the NHMS has formed a partnership with the private sector (see Chapter 8). In most cases, such partnerships have been between the aviation industry and the NHMS, as mandated by international law. In the last decade – with the increased uptake of mobile phones in Africa – partnerships between mobile phone companies and the NHMSs have also emerged. These partnerships can serve to facilitate the dissemination of weather information to a wide range of end users and have been implemented in several African countries – for example Kenya, Uganda, Zimbabwe, Ghana and Mali. Details on the operation of these partnerships are presented in the case studies in Annex C6 and can serve as examples of best practices and lessons learned for the 11 countries supported by the CIRDA programme.

In these cases, the mobile phone companies are willing to work with NHMSs because the provision of even basic weather information products to their customers – as part of a wider suite of desirable content – pays back over time. Such basic weather information products catalyse value-added uses of other telephony services that are: i) profitable; ii) improve the lifecycle of mobile subscription; and iii) attract new customers. There is also scope for mobile phone operators to assist the NHMSs by providing secure sites on their cell phone towers for installation of automatic weather stations. This would significantly reduce installation costs and greatly improve the quality of observation data collected from the ground observation network. However, the mobile phone companies ultimately require – but are not necessarily prepared to pay for – the final, carefully tailored weather information product rather than raw weather data.

International climate services providers are already providing such tailored services, often without cooperation of and coordination with the NHMSs or the data they generate. However, the forecasts and products developed by the private sector can often be improved by the provision of accurate, reliable and consistent data from the NHMSs. This would involve the NHMSs increasing their capacity to provide products for model input, forecast verification and development of improved Model Output Statistics (MOS). Consequently, if the quality of the services that the NHMSs provide to the private sector improves, then the NHMSs could partner with companies and provide a competitive advantage in an increasingly crowded marketplace. This is particularly true for specialised private weather companies[113] that focus on the bundling of basic climate and weather data from satellites and ground observation networks. These companies sell such data to organisations for forecasts, climate modelling and other diverse applications. Specialised private weather companies could assist NHMSs to develop their capacity to participate in the private weather market. Successful entry into this market requires very specific technical and commercial skillsets because it is not only highly competitive but also extremely price- and value-sensitive.

PPPs can improve the functioning of the NHMS as a whole, or through supporting specific responsibilities that the NHMS is mandated with. Examples of such specific responsibilities include development of forecasts and maintenance of the national observation network. Each of these involves enhancing arrangements between the NHMS and the private sector partner as well as defining the outcomes and outputs of the PPP. It should be noted, however, that regardless of the NHMS's model, it is imperative for the NHMSs in Africa that financial support from the government – directly or indirectly through service level agreements – is committed to support the operation and maintenance of the required basic infrastructure.

[113] such as Speedwell Weather

### *9.2.1 Operating models for the NHMSs*

In this market study, five potential operating models for NHMSs were identified: namely a: i) Departmental Unit; ii) Contract Agency; iii) Public Body; iv) State-Owned Enterprise; and v) Privatised Company. These are considered further below, and illustrated in Figure 9.1.

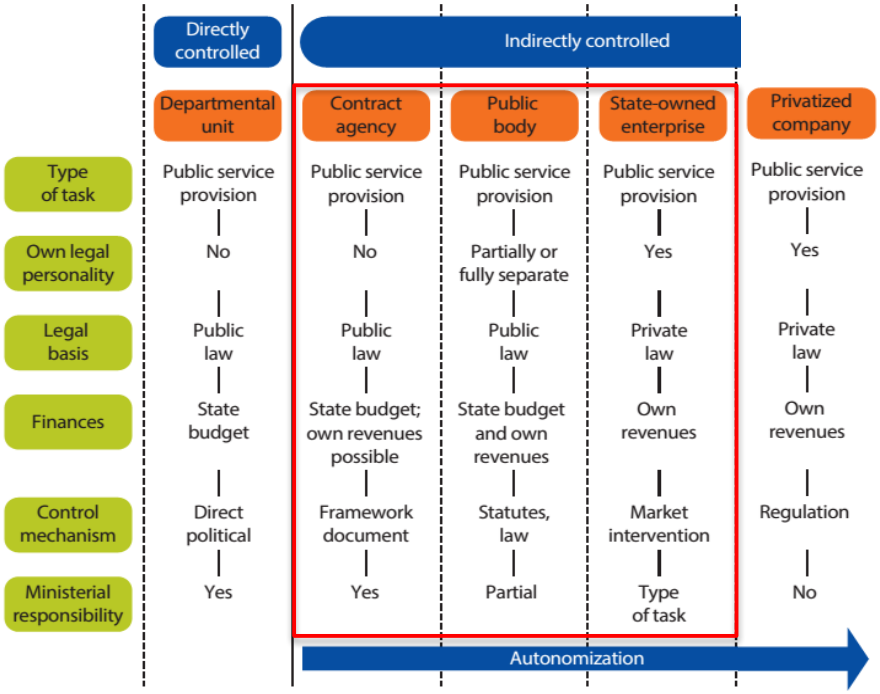


**Figure 9.1.** Five operating models for the NHMSs (adapted from Gill 2002; Greve, Flinders, and Van Thiel, 1999.)

At present, most NHMSs are directly controlled by government and established as a departmental unit (usually within a government ministry). These departments are subject to all public finance laws and regulations that govern the country. As a result of this institutional framework, undertaking any direct profit-making activities with the private sector are frequently restricted or even impossible owing to contracting, procurement and other difficulties (e.g. in *inter alia* São Tomé and Príncipe, and Uganda). Models whereby government indirectly controls the NHMS are being considered in some of the countries supported by the CIRDA programme. The advantage of these indirect models – which include contract agencies, state-owned enterprises, and public bodies" – is that they typically have more flexible regulations governing procurement, revenue raising ('trading') and contracting, relative to direct models. As a result of this flexibility, developing public-private partnerships (PPPs) is easier when involving agencies, public bodies and state-owned enterprises than with government departments. During the last 20 years, successful examples of privatisation of NHMSs have been demonstrated in developed economies. Notable amongst these are the United Kingdom (UK Met Office), France (MeteoFrance), the Netherlands (Royal Dutch Meteorological Institute, or KNMI), and New Zealand (MetService, trading as MetraWeather).

In Africa, several countries – including Liberia and Malawi – are in the process of transforming their NHMSs from departmental units into public bodies. However, such transformation is likely to be challenging unless this process promotes fundamental changes in the structure, resourcing and behaviour of the NHMS. These changes are necessary because government departments in Africa currently do not pay for services from other government departments, and are thus unlikely to be willing to pay for climate products and services from NHMSs unless they have transformed to public bodies. Additionally, in some countries where there is a transition of NHMSs towards contract agencies, it seems that the governments are expecting them to become autonomous. However, government funding remains essential to maintain core functions of the NHMSs, including provision of early warnings and maintenance of the observation network. Central to this institutional reform is the consideration that government funding – an appropriation, or input-based, model when applied to departments such as NHMSs – can transform to output or outcome based in the new NHMS institutional model. Governments can thus move from being mandatory 'funders' towards value-sensitive customers, or investors, who purchase goods and services from the new NHMS agency.

State-owned enterprises – or parastatals – operate under private law since they have managerial autonomy. This type of model applies to NHMSs that are encouraged to compete directly within the commercial market. Examples of this model include MetraWeather in New Zealand and the Royal Dutch KNMI in the Netherlands.

MetraWeather is a good example of how commercial activities that focus on provision of forecasting information prove more profitable than merely the provision of observational data. However, there are many free online weather platforms that provide global weather information, which private weather companies can access and use to generate localised data and forecasts. The NHMS therefore needs to offer a unique service based on their competitive advantage over private weather companies, such as providing continuity and being neutral as the NHMSs have no profit making interest (see Chapter 5). The challenge of offering unique and distinct services has been recognised by the WMO as the cause of a strongly competitive relationship between the private sector and NHMSs. To reduce competition and develop their unique services, NHMSs need to be open to collaboration and determine the best method for engaging with the private sector.

### *MetraWeather*

*Background to MetraWeather and their presence in Africa*

During the 1980s, there was increasing pressure on government funding for meteorology in New Zealand, as well as a government-wide move to: i) encourage the "user-pays" principle for specialised services; and ii) increase autonomy and accountability for government departments. A combination of commercial competition in the deregulated market for meteorological services and reform of publicly-funded science led to the establishment of the Meteorological Service of New Zealand Ltd (MetService) as a State-Owned Enterprise (SOE) in July 1992. However – given the small size of the New Zealand weather market – MetService has sought additional revenues and markets abroad through its commercial branch, MetraWeather – which provides services solely for international markets. This transition was accompanied by the establishment of an exclusive national market that offered a secure home market for the new privatised service.

*Relationship with MetService and benefit sharing*

Although MetraWeather is the commercial branch of the NHMS, the government still provides financial support for executing core duties of MetService, e.g. EWS. All other localised activities and tailored requests within and outside New Zealand are undertaken by MetraWeather.

MetraWeather benefits from the government being the anchor customer (and owner), with multi-year service contracts negotiated on a commercial basis between the parties. This approach is output linked (hence based on value received), rather than input linked (as most government appropriations models are), and closely resembles typical private sector procurement. But MetraWeather also benefits from a regulatory framework that prevents other private sector weather services from operating in the country, thus affording MetraWeather exclusive access to the national market.

MetraWeather also operates in some developing countries, particularly in SE Asia. For example, it has an office in Thailand. Access to large amounts of accurate data is important for MetraWeather's operation and requires close collaboration with the host country's NHMS. For example, in Thailand, MetraWeather partnered with a business that has close ties to the NHMS. This business delivers modelling services, disseminates information and acts as an intermediary between MetraWeather and Thailand's NHMS.

*Sources of revenue*

Overseas revenues – through MetraWeather – are estimated at 15–20% of their income. Government contributions are 5–10%, with the rest coming from aviation, transport and the media.

An additional example of an NHMS that privatised its commercial interests is the Royal Dutch KNMI in the Netherlands. Like MetraWeather, this process was not driven by the NHMS itself, but emerged from a political decision within the Netherlands that promoted a market-based economy. Funding for KNMI's core duties is provided by the Dutch government, but substantial additional revenues are also derived from collaboration with private weather companies and through PPPs. More information on the transformation from government body to an autonomous entity within the KNMI is described in the text box below.

**The Royal Dutch Meteorological Institute (KNMI)**

In the mid-1990s, the Dutch government moved towards a neo-liberal approach whereby government departments were encouraged to separate public and market domains. The Dutch NHMS – the KNMI – was the first entity to undergo such separation. The KNMI is more advanced than other NHMSs in the developed world because the separation between the public and private market increased the rate of development of weather products and services. The KNMI is currently mandated to provide services to the central government. Moreover, as a result of the amended mandate to separate public and private domains the division of roles and responsibilities between the KNMI and private sector are clear and the KNMI can focus on its core strengths. However, this is only possible because government funding for these core strengths is available. If KNMI did not have access to government funds, private users would need to be engaged, which would result in competition with private companies.

Currently, some collaboration exists between the KNMI and private weather companies regarding weather warnings. The legal framework grants the KNMI the authority to send out such warnings. To avoid multiple – and possibly contradictory – warnings on severe weather, the KNMI manages their dissemination in collaboration with private weather stations, thereby creating "one voice" for forecasts. [Given that the KNMI does not have any contracts with the media, private companies are responsible for the timely delivery of weather warnings by the KNMI to the media[1].

In 2015, a new law revised the mandate of the KNMI to allow the formation of PPPs providing that the KNMI remains transparent. This decision was taken as the liberal Dutch government would like to reduce government support as much as possible. PPPs can be exclusive for a maximum of one year. In addition, the knowledge developed through the PPP has to be publicly available after the year-long contract has elapsed. The income that KNMI receives from the private weather companies through PPPs then contributes to the cost recovery of the maintenance of the datasets.

In the African context, the transformation from government body to an autonomous entity will be more challenging as most NHMSs in developing countries do not have adequate funding to maintain existing infrastructure and observation networks. Without this support from government, it would be risky for the NHMSs to invest in expensive equipment that is costly to maintain and often not compliant with international standards. An alternative option, over the short-term, would be for the NHMSs to focus on enhancing their dataset using weather variables that are accessible through the internet and from satellites to increase their revenue. Since generating this information is in the national interest, funding for this can be provided by the government[114] at a more affordable rate. However – in the medium- to long-term – this core funding from government should be gradually shifted towards greater investment into the expansion of ground observation networks.

*9.2.2. Potential funding models*

The considerable socio-economic benefits of a well-functioning NHMS should be presented in awareness raising campaigns targeting government as well as the general public. Included in this material should be the likely returns derived from investments in the NHMS human resources and infrastructure. The objective of the awareness raising campaigns would be to generate greater political support for the NHMSs and ultimately greater funding streams from government as well as the private sector. The national treasury would be a particularly important target audience for this awareness raising, as the benefits of a well-functioning NHMS are ultimately a public good.

Furthermore, a fair revenue-sharing mechanism needs to be put in place to create an incentive for the NHMS to continue to invest in improved weather products and services. Currently, payments for weather data by the private sector often go directly to the central government – for example national treasury or the Ministry under which the NHMS falls – without being earmarked for re-investment in the NHMS. Revenues are thus distributed among the different departments under the respective Ministry or across other ministries

[114] Personal conversation with Mr Wichers-Schreur on 21 October 2015.

according to government priorities. This is an example of a typical centralised national treasury, budgeting and appropriations process. If these revenues are not returned to the NHMS – either directly or indirectly – this will act as a disincentive to innovate and develop new tailored products and services.

As revenues from sales of climate services are rarely returned to NHMSs, there is a perception that the NHMSs are not compensated adequately for the sale of the products that stem from their efforts. To address this, a representative from the Zambia NHMS proposed a model whereby the government receives ~20% of the fees collected for products and services, with the remaining ~80% going directly to the NHMS[115]. Models from other sectors often use such a "soft-earmarking" approach. This would entail an agreement with national treasury to make annual budget allocations to the NHMS in proportion to the income streams generated from sales of tailored weather products or services. Estimates of the value of weather information indicate that a 30-year time series of daily temperature and precipitation data from one climate monitoring station could sell for approximately $500[116]. However, NHMSs are rarely able to obtain the revenue that they expect from sales of such data. They therefore experience challenges in transforming into autonomous entities that can generate revenue independently from government budget allocations.

Evidence from Europe and New Zealand indicates that transformation towards an autonomous NHMS is at least a 10-year process. Given this, the adoption of a pathway for transformation consisting of two phases is proposed. The first phase would include a grant-based, 3–5 year "testing the market" intervention. The purpose of this first phase is to build technical capacity within the NHMS, as well as to identify entry points into main private sector markets – including potential private weather company partners. Once the NHMS can access the commercial weather market and generate some additional revenues from sales of climate services, the second phase would begin. This phase would comprise a transition towards an agency model, where the government slowly shifts from being the funder to the customer. This second phase would entail the NHMS receiving a smaller portion of revenues from national treasury than it would as a government department, while new private sector products are developed and sold by the NHMS.

## 9.3 Proposed partnership approach

NHMSs are not in the business of developing a market from the bottom up i.e. creating the demand through marketing and then developing the sophisticated products. Moreover, it is difficult to set up a profitable business model in the weather sector based on a single product. Rather, successful businesses in this sector usually rely on a range of value-added products. Particularly specialised private weather companies can assist NHMSs in this regard as they do not directly compete with the NHMSs in their core responsibilities of generating weather data. Instead, private weather companies are value adders, focusing on technologies rather than weather forecasting. These companies provide data – whether from ground observation stations or satellites – to other businesses or end users. By forming a PPP with a NHMS, these companies could assist the NHMS with improving the quality of their weather products and services, as well as increase their engagement with the private sector end users. Specialised private weather companies are entirely market focused, and are structured in such a way that they do not carry the human resourcing and infrastructure overheads that a NHMS does. This allows these companies to be flexible, and to invest a greater share of their resources in promoting the private sector market. In addition, these private weather companies have the potential to provide assistance to the NHMS by supplying modern technology that will improve the quality of information that is generated.

Earth Networks has introduced a model of joint data processing and information sharing through partnerships, while leveraging technology that is context specific. To do this, Earth Networks facilitates the establishment of PPPs – for example between the NHMS and mobile phone companies – to assist the NHMS with developing and selling weather products that can generate revenue. The profits of these sales are shared with the NHMS, thereby creating an additional revenue stream for the NHMS. This joint data collection process is supported by the WMO as a best practice for engagement between NHMSs and the private sector.

Since aviation is a sector with which NHMSs already have existing relationships, and to which they already supply tailored products, there is an opportunity to further engage with carriers and airports to expand and improve the supply of tailored products. However, it

[115] Personal conversation with representative NHMS Zambia at the CIRDA workshop in Addis Ababa 26 August 2015.
[116] Personal conversation with David Whitehead Speedwell Weather on 30 October 2015.

is important to first consider: i) the true costs to NHMSs of the existing tailored services that are provided and the associated cost recovery arrangements; and ii) the need for mechanisms to expand the supply of additional tailored products to the sector. Since carriers are already using private weather companies, and require a wide range of products that address a variety of needs, the risk to NHMSs is that disintermediation by private weather companies would result in loss of the market share in the fast-growing African aviation market.

Other companies that would be appropriate partners for the NHMS are those that provide a communication platform for buyers and sellers and have experience in crossing the Last Mile – for example the company ESOKO. To form a PPP with these companies, the NHMS would have an agreement with an intermediary – such as ESOKO – that will assist in developing the tailored products and services that are in demand. Moreover, these companies would be a suitable partner to: i) engage with the NHMSs for collecting country-specific data; ii) influence and support the local NHMS to improve their data collection and curation in a way which favours them; iii) fundraise jointly for WIBI and other products; and iv) compete with other private weather companies.

Lessons learned from joint projects with mobile and insurance companies – for example in Uganda and Malawi – indicate that a direct partnership between the NHMS and these companies is not feasible because of *inter alia* limited: i) technical capacity of the NHMS to generate products and services that can be sold for profit; and ii) business skills required to engage with the private sector. However, opportunities exist for the countries supported by the CIRDA programme to form PPPs with different type of companies that are already in the market and engaging with the private sector end users.

Another potential arrangement for PPPs has been demonstrated by Airtel. With the responsibility for app hosting and information delivery, Airtel is well suited to becoming a third partner in a PPP, since it has a strong competency hosting mobile applications and delivering diverse content to a wide base of subscribers. While this is a slightly more complex construction than when just two entities are involved, it makes the delivery of the final product more effective than if it were left to the NHMS to do so. Moreover, Airtel has a vested interest in ensuring that the NHMS remains involved and provides timely, accurate climate and weather information to maintain Airtel's reputation as a premium service provider. Moreover, with a typical lifespan of between 18 and 21 months for a pre-paid customer, the pre-paid market in many African countries is fiercely competitive. The main reason for people deciding to change service providers is the cost associated with using the service provider. However, "life enhancing" apps are playing an increasingly important role in this decision. The potential therefore exists for mobile service providers to include weather info apps as a means of attracting and retaining customers.

Given the considerable complexity of the private market that supplies climate and weather information – which includes customers as diverse as mining companies to subsistence farmers – it is suggested that the NHMSs that are in the most advanced state of readiness engage with private weather companies and business development partners to pursue the "low-hanging fruit". Examples of companies/sectors that are more inclined to partner rather than compete with the NHMSs include mobile phone operators, the aviation sector, and partners that specialise in packaging and on-selling weather data.

Each potential partnership between a NHMS and private sector company would need detailed evaluation and negotiation. This market assessment found that the national weather market would grow most effectively if the partnerships were established in a competitive, non-exclusive, and performance-based manner. Exclusive partnerships, preventing the NHMS from engaging with other companies, would potentially have a stifling effect on the national commercial weather market, because different companies are likely to make different contributions to the growth of the market. NHMSs can also form PPPs by engaging in a partnership comprising of both public and private sector representatives. Such a partnership is beneficial to the NHMSs as they gain access to the expertise of both NGOs and the private sector to improve the production and dissemination of their weather products and services. Examples of recently established multi-stakeholder partnerships are described below.

*Climate Services for Resilient Development*

The Climate Services for Resilient Development partnership was launched in 2015 with more than US$34 million in financial and in-kind contributions from eight founding-partner institutions from around the world. These include the US government, the American Red Cross, the Asian Development Bank, Esri, Google, the Inter-American Development Bank, the Skoll Global Threats Fund and the U.K. government. Initial activities include the development and application of scalable, replicable, comprehensive and integrated climate services in Colombia, Ethiopia and Bangladesh. The objective of the partnership is to deliver tailored and targeted climate services to countries in sub-regions of Latin America (the Andean region and Caribbean), Africa (East Africa and the Sahel), and Asia (South Asia and Southeast Asia)[1].

The partnership that led to the formation of Climate Services for Resilient Development is the first in the world in which government, private sector and NGOs are collaborating to improve the product and service delivery of the NHMSs to the public. Similarly, the Red Cross Climate Centre comprises a partnership between NGOs, donors and national governments. These partnerships both demonstrate promising results and lessons learned can be replicated in other countries, including the countries supported by the CIRDA programme.

*The Red Cross Climate Centre*

This Red Cross Climate Centre (hereafter, Climate Centre) is a specialist reference centre of the International Federation of Red Cross and Red Crescent Societies (IFRC). The IFRC and the Climate Centre began a partnership with the International Research Institute for Climate and Society (IRI) at Columbia University in New York in 2007. The objective of the partnership is to develop and supply tailored forecasting and weather products to help IFRC disaster managers predict, prepare for and respond to disasters worldwide. In Africa, the Climate Centre is supporting the IFRC in a consortium led by the WMO in a Norwegian-funded programme to implement the Global Framework for Climate Services in Malawi and Tanzania, the first programme of its kind.

- In Malawi, the initiative is strengthening the links between meteorologists and people who would benefit from the integration of climate and weather information.
- In Tanzania, climate information is not available in a format easily accessible to vulnerable communities. The initiative is promoting climate change adaptation through community outreach, development of contingency plans and strengthening the understanding of local communities of climate risks.

## 9.4 Potential companies and organisations identified to partner with the NHMS in the countries supported by the CIRDA programme

Based on consultations with representatives from the private and public sector, a number of relevant companies have been identified as potential partners for NHMSs in the countries supported by the CIRDA programme. A brief description of these potential partners and why they are identified as such is summarised in Table 9.2 below. A next step for the NHMSs would be to conduct national market assessments of the potential opportunities for generating revenue from a wide range of clients.

**Table 9.2.** Overview of potential partners for the NHMSs in the countries supported by the CIRDA programme.

| Name company or organisation | Objective | Why potential partner for NHMS? |
|---|---|---|
| MESA programme of EUMETSAT | Supporting the African meteorological community in the development or strengthening of | MESA can potentially assist with fundraising and/or capacity building for the NHMS. For example, fund part |

| | | |
|---|---|---|
| | their capacity to deliver appropriate climate and weather information to decision makers in their countries and regions. MESA particularly focuses on strengthening capacities for the use of Earth Observation in Africa with an emphasis on climate and environment applications. | of the first pilot phase of an NHMS as it develops climate services. |
| Partners for Resilience (PfR) alliance (comprises CARE Nederland, Cordaid, the Netherlands Red Cross, the Red Cross Climate Centre and Wetlands International) | Developing projects focussing on local climate-smart strategies that reduce the risk of disaster by focusing on ecosystem management and restoration. | The PfR alliance is currently operating in Ethiopia and Uganda, but has the potential to expand to other countries supported by the CIRDA programme.<br><br>The PfR collaborates closely with the NHMS and the national research institutions However, to address complex problems effectively, partnerships with representatives from multiple relevant sectors is required. |
| Agriculture and Climate Risk Enterprise Ltd. (ACRE) | Linking farmers to insurance products so that they can confidently invest in their farms. In addition, the company is working directly to improve the capacity of local insurance companies to add index products to their portfolios. | ACRE is already present in East Africa – including Tanzania. Through partnering with the NHMSs, ACRE will be able to provide insurance against extreme weather events and changes in climate to farmers in the countries supported by the CIRDA programme. |
| CGIAR | Contributing to food security and poverty eradication in developing countries through research, partnership, capacity building and policy support, | CGIAR has extensive experience in East and West Africa – including some countries supported by the CIRDA programme – on identifying climate and weather needs of farmers. The organisation could assist the NHMSs in tailoring their products to the farmers' needs. |
| Earth Networks | Assisting consumers, governments and enterprises worldwide to respond to current weather conditions, forecasts, and severe weather alerts. | Earth Networks already has experience forming a public-private partnership with an NHMS in a Least-Developed country in Africa (Guinea). Following this experience, the company can enable and strengthen other African NHMS's ability to actively monitor and predict thunderstorms and issue timely and relevant early warning of dangerous weather conditions. |
| ESOKO | Using technology as a solution to collect and share market prices via SMS. | ESOKO can facilitate the dissemination of weather information from the NHMSs to the local people. |
| Speedwell Weather | Providing high quality global weather data, weather forecasts, software, and | Speedwell Weather does not directly compete with the NHMSs because the |

| | | |
|---|---|---|
| | consultancy. In particular, the company supplies quality historical and real-time weather data for tens of thousands of sites across the globe. | company is a value adders and focusses on technologies rather than weather forecasting. Through forming a PPP with a NHMS, Speedwell Weather could consequently potentially assist the NHMSs with improving their weather products and services, as well as increase their engagement with the private sector end users. |
| FIT Uganda | Collaborating with partners in social responsive strategies to support and facilitate sustainable development through access to market programmes, enterprise development, business linkages and feasibility assessments. | FIT Uganda could build the capacity of the NHMSs to develop a business skillset to engage with the private sector. |
| iShamba | Providing weather alerts, market price information and special offers tailored to the crops and livestock in the area of the farmer. | The company provides free sms service for farmers including weather alerts. Through a call centre, farmers can ask iShamba for agricultural information. Experience working with NHMS and private weather companies. |
| TAHMO | Developing a network of weather stations across Africa. The TAHMO project is committed to serving the public by advancing the free and open exchange of hydro-meteorological data collected with its monitoring stations. | TAHMO can support the NHMSs in providing ground observation station that are easy to maintain and located at accessible places such as schools. |
| Vodafone Farmer Club | Assisting farmers to increase productivity by providing information on meteorological data, market prices and other information related to the products farmers cultivate. | The company showed interest in starting the Farmers Club initiative in Tanzania. Considering the requirement of a good banking system this seems more interesting for East Africa. |
| Arcelor Mittal (Liberia) | Supplying high quality steel products in all major markets including automotive, construction, household appliances and packaging. | Arcelor Mittal is operating a number of mines in Liberia. Their operations are seriously affected by e.g. flooding. Consultations with the company in November 2015 they stressed the need for the NHMS to provide weather information in an accurate and punctual manner. |
| Airtel (Sierra Leone) | Facilitating communication between people. | Airtel's core businesses are data and voice. Not app development. There is an opportunity for the NHMSs to own |

| | | |
|---|---|---|
| | | an app that delivers detailed climate and weather information[117]. |

## 9.5 New technologies

New technologies in the weather market can assist NHMSs with increasing the accuracy and cost-effectiveness of their products and services. The NHMSs in Africa, however, have restricted access to these technologies as a result of limited infrastructure and funding. Opportunities for NHMSs to produce accurate weather data are thus often restricted. This has been recognised by research institutes and companies who view this as an opportunity for growth and have begun therefore to increase their focus on improving capacity for collection of weather data in Africa. This has resulted in the implementation of projects such as the Trans African Hydro Meteorological Observatory (TAHMO). TAHMO works with schools and NHMSs to expand the number of weather stations across Africa, thereby increasing the amount of data that can be transferred to the observational network. There are many other initiatives that focus on improving weather data in developing countries that can be replicated and used within the countries supported by the CIRDA programme. Examples of such technologies are summarised in Table 9.3 below.

[117] Based on personal conversation between Mr J. Hoedjes and the managing director of Airtel in Sierra Leone in November 2015.

**Table 9.3.** Overview of potential technologies to improve the development and dissemination of weather information in the countries supported by the CIRDA programme.

| Technology | What is it? | Where? | Benefits |
|---|---|---|---|
| 3D printed weather stations[118,119]. | 3D printers can produce nearly all of the necessary parts to manufacture accurate, reliable weather stations. The only non-3D printable components are sensors. | Zambia | • This economical option provides a viable solution for developing nations.<br>• As a result of the replicability of the separate parts, the stations can be established in any area, including those where formerly this was too expensive.<br>• NHMS will receive equipment including laptops onto which the 3D designs for the various parts are loaded. |
| Mobile weather stations[120] | Mobile weather stations can capture and transmit near real-time data on rainfall. There are also low cost Open Design, Open Source Hardware and Open Source Software solutions for weather monitoring. | Sri Lanka | • Easily replicable through open source software.<br>• Low cost (US$250) and sourced from local materials.<br>• Raises the alarm in the event of extreme rainfall and other natural disasters, which can help farmers and disaster management officials take the necessary precautions. |
| Weather Transmitter WXT530 Series[121] | The transmitter is a unique set of sensors that allows for the selection of weather parameters that best fit the customers' measurement needs and application. It has the ability to measure air pressure, temperature, humidity, rainfall, wind speed and wind direction in various combinations. | Globally | • Flexible monitoring of real-time weather conditions.<br>• Cost-effective<br>• Choice to monitor only one condition or all conditions, as well as the option to add third party sensors. |
| Storm prediction system by NOAA NEIS | The system synchronises NOAA data and collects millions of data points from all over the world to create a four-dimensional model of the world's weather. NEIS™ displays the data through GSD's multi-platform tool, TerraViz™ | United States | • This system is able to predict storms with more precision as a result of using millions of data points across the world. |

Automatic weather stations on cell-phone towers

[118] http://3dprint.com/53995/3d-printed-weather-stations/. Accessed on 2 November 2015.
[119] http://www.bloomberg.com/news/articles/2015-04-13/it-s-now-98-cheaper-to-forecast-weather-with-these-little-kits. Accessed on 2 November 2015.
[120] http://www.downtoearth.org.in/news/these-mobile-weather-stations-can-help-cope-with-floods-landslides-48760. Accessed on 25 November 2015.
[121] http://www.vaisala.com/en/press/news/2015/Pages/Page_1958205.aspx. Accessed on 17 November 2015.

In addition to the technologies highlighted in Table 9.3, siting AWSs on cell-phone towers has been suggested for NHMSs in Africa. Unlike synoptic stations – which are expensive to establish and maintain, and have strict guidelines on where they may be placed – siting AWSs on cell-phone towers is cost effective since they piggyback on existing infrastructure which is powered and secure. In addition, maintaining these AWSs is inexpensive since technicians working on the tower could potentially also repair and maintain the AWSs. Finally, there is also an easy and reliable means of communication of weather data to a central database owing to its integral placement in the mobile network.

The placement of AWSs on cell-phone towers also facilitates the establishment of a ground observation network with good resolution of data owing to optimal coverage. This is because Global System for Mobile Communications (GSM) macro-cells are small – compared to the size of cells needed for observation networks – with cell sizes of radius up to 20 km. Consequently, the effectiveness of the national coverage will be significantly enhanced. An additional benefit of siting AWSs on cell-phone towers is the improved value of the overall national dataset of the NHMSs when developing tailored climate and weather products for the private sector. A good example of this can be found with the EcoFarmer model in Zimbabwe where AWSs are hosted on the EcoNet mobile telephony network (EcoNet owns EcoFarmer). A similar strategy of siting AWSs on existing infrastructure – in this case along railway lines – has been employed in Zambia. While this may be useful for some purposes, the data returned from this network was found to not be suitable for Weather Index-Based Insurance products. This was ostensibly because railway lines are largely linear and would not provide the kind of coverage and resolution needed for WIBI products. It is therefore necessary to compare the type of coverage required with the proposed infrastructure before making investments into the networks.

A disadvantage to siting AWS on cell-phone towers is that the weather data that is collected may not necessarily be compliant with WMO standards and therefore cannot be shared on an international scale. However, data generated from AWS can provide local-scale detail that, when complemented with data from synoptic stations, provides important local detail within the global climate record[122]. Considering that relatively few synoptic stations are required to characterise regional-scale climate and weather, it is suggested that NHMSs pursue the establishment of widespread networks of non-synoptic AWSs on cell-phone towers in partnership with national MTOs, and initiatives such as TAHMO. Supplementary data generated from these AWSs should therefore undergo inter-comparison checks with data from nearby synoptic stations that have high quality, well-calibrated sensors. Sensors from the local observing (mobile mast) AWS can be rotated through an inter-comparison (an exposure for a month or more) with the synoptic sensors, and a correction factor can be determined for that sensor and used in the QA/QC process when the sensor is re-deployed on the mobile mast AWS. For example, if a temperature sensor in an all-in-one AWS consistently reads 0.5 °C less than the synoptic station temperature sensor, then a correction of 0.5 °C can be made via software when field temperature values are gathered[123]. This would offset most of the error from the mobile mast AWSs.

To further support the provision of tailored weather technologies for end users, an increasing number of universities are involved in providing training to the NHMSs in developing countries. For example, the Walker Institute of the University of Reading has developed the Participatory Integrated Climate Services for Agriculture (PICSA) approach. This approach comprises three elements, namely: i) combining historical climate data with location-specific crop and livestock information so that farmers can assess risks; ii) using planning tools to consider crop, livestock and livelihood options and make decisions accordingly; and iii) adapting livelihood strategies based on seasonal and short term forecasts[124]. Similar initiatives could be used to provide training for the NHMS staff in the countries supported by the CIRDA programme.

[122] http://undp-cirda.blogspot.co.za/2015/11/understanding-wmo-guidelines-and-their.html. Accessed on 19 January 2016.
[123] Personal communication with Professor John Snow, December 2015.
[124] http://www.walker-institute.ac.uk/research/PICSA/. Accessed on 2 February 2016.

# 10. CONCLUSIONS

Private weather companies providing climate and weather information are growing rapidly in number and size, are highly competitive, have become global in reach, and are becoming increasingly sophisticated – all of which reflects a strong global market demand for tailored climate and weather information products. These companies are continually innovating to expand the market for their products and services by improving supply while also growing demand. On the supply side, technology (e.g. numerical global forecast models underpinned by ever increasing amounts of satellite data) is being used to increase the value of the products to the customer. On the demand side, intensive marketing is being undertaken to increase awareness across a wide range of economic sectors of the existing diverse array of tailorable climate and weather information products.

Where markets for climate and weather information products have developed particularly successfully – e.g. in the USA and the Netherlands – NHMSs have been central to the process. A fundamental role of the NHMSs in these cases has been to provide good quality data and derived products from their extensive observation networks. This has enabled private weather companies to improve both the quality and the quantity of their products and services, and to develop new markets by providing tailored products and services catering to the needs of specific niches. Such government-provided data invariably underpin the growth of the commercial weather market, enabling companies to thrive. Another effect of a flourishing commercial weather market is to increase the status of the NHMS within both the private and public sectors, which in turn facilitates investments by government and the private sector into building the human resource capacity as well as infrastructure of the NHMS.

This market assessment investigated how flourishing commercial weather markets could be catalysed in the countries supported by the CIRDA programme, and how NHMSs could maximise their benefit from such markets. Two main conclusions emerged from the assessment. Firstly, NHMSs should **collaborate rather than compete** with private sector weather companies; and secondly NHMSs should embark on **phased, slow transitions** into entities that derive benefits from the national commercial weather markets. These two conclusions are elaborated upon in the sections below.

## 10.1 NHMSs should collaborate with rather than compete with private sector weather companies

The primary assumption underpinning this market assessment was that NHMSs will derive the most benefit from the private sector if the national commercial weather market is thriving. The reason for this assumption is twofold. Firstly, the national commercial weather market can potentially develop large revenue streams (from the provision of sophisticated weather information products and services) in which NHMSs could share. And secondly, NHMSs do not yet have the appropriate skills (nor is it their core business) to develop such revenue streams.

Many of the products that the private weather companies will develop in a thriving national commercial weather market will be niche products i.e. highly tailored products meeting the requirements of particular customers. For example, a mining company may want a tailored weather forecast delivered on an hourly basis that advises the management of the company whether they should be adjusting their operations at a particular mine according to the expected weather conditions. A different mining company may want a product that is delivered only when certain weather thresholds are exceeded for a given mine. Successfully establishing such niche products in today's competitive market place will usually require considerable marketing, technological, and business development skills, all of which are unlikely to be present within an NHMS. The private weather company may, for example, need to invest in a multi-year marketing campaign that builds awareness in the mining sector that such niche products can greatly reduce operational costs at a mine. Once a mining company is convinced of the value of such a product, the private weather company may then need to develop – very quickly – a tailor-made software application that integrates seamlessly into the mining company's own IT system. This business development cycle, including the marketing, scoping of needs, and finally development of the products can take up to five years.

Private sector weather companies are commercially incentivised to develop and market new niche products, and to be continuously innovating to improve the experience of the customer and the value of the product to the customer. NHMSs – even if separated from government in the form of an agency – do not share the same commercial incentives as private weather companies because their mandates are fundamentally different. Whereas the NHMSs (and associated agencies) are tasked with serving the public and providing public goods in the form of climate and weather information, the private weather companies are seeking to maximise their profits within highly competitive private sector markets. The skills within the NHMSs and private sector companies will consequently by definition be very different.

Assuming that NHMSs are likely to benefit most from a thriving commercial weather market, and that the skillsets of the NHMSs and private sector companies will invariably differ, a reasonable conclusion to reach is that NHMSs and private sector companies should partner rather than compete. Such partnerships would promote the national weather market and result in the growth of private sector revenue streams that the companies could share with the NHMSs. An additional effect of NHMS-private sector company partnerships would be incentivising the NHMSs to improve their internal systems such that there is a guaranteed provision of high quality data on a regular basis to their private sector partners (as per individual service level agreements).

Each commercial relationship between a NHMS and private sector company would need detailed evaluation and negotiation. This market assessment found, however, that the national weather market would grow most effectively if these public-private relationships were established in a competitive, non-exclusive, and performance-based manner. Exclusive partnerships – for example, ones preventing the NHMS from engaging with other companies – would potentially have a stifling effect on the national commercial weather market, because different companies are likely to make different contributions to the growth of the market.

The extent to which a particular NHMS contributes to the development of commercial weather information products will depend on the local context such as the technical capacity and appetite for innovation within the particular NHMS, as well as the business objectives of the private sector weather companies operating within the country. As mentioned above, the skillsets of the private sector companies operating in countries supported by the CIRDA programme are considerably more suitable for development of sophisticated niche products than the skillsets within the NHMSs. It is therefore likely that it would be most appropriate for the NHMSs – in the context of commercial relationships with private weather companies – to focus on providing general public forecasts, together with alerts and warnings of impending hazardous weather, and consistent, high quality data from their observation networks. The NHMS would then rely on their private sector partners to be developing and marketing innovative and sophisticated niche information products to supply a range of different customers.

Private weather companies are not, however, dependent on receiving data from NHMSs because products derived from satellite data can be of sufficient quality to generate sales and better than what can be obtained from public agencies. These companies are consequently not beholden to the NHMSs. It is rather the NHMSs – as a result of their limited skillsets in developing weather markets – that face the considerable risk of being marginalised if they do not actively promote the growth of the market by providing consistently accurate primary data to the private sector. Such marginalisation is highly undesirable from a public perspective because a growing, diverse market for commercial weather services serves both public needs and private interests.

This market assessment also found that there is a wide range of private sector companies – including mobile phone companies, mining houses, weather data providers, and weather forecasters – that are willing to engage directly with the NHMSs in countries supported by the CIRDA programme. Companies that specialise in the provision of aggregated and packaged primary weather data emerged from the assessment as particularly suitable for partnerships with those NHMSs that are moving into private sector engagements for the first time. This is because the product that such companies sell – i.e. primary weather data – is exactly what NHMSs have the inherent capacity to produce if their ground observation networks are functioning well. The potential value of the partnership between a NHMS and a company specialising in provision of weather data was highlighted by the fact that one of these companies noted that they would be prepared to invest in the infrastructure and training of the NHMSs in the countries supported by the CIRDA programme.

## 10.2 NHMSs should embark on phased, slow transitions into entities that derive benefits from the national commercial markets

NHMSs in the countries supported by the CIRDA programme have historically had minimal engagement with the private sector, apart from providing weather information to the aviation sector. As a result, there are relatively limited skillsets in the NHMSs for working with private sector companies, particularly in regard to negotiation of appropriate partnership arrangements. Such negotiations would, for example, need to maximise revenue sharing via royalties or fixed fees over the long term. Given the limited private sector negotiating skills within the NHMSs, and the complexity of the commercial weather market, there is considerable potential for NHMSs to take inappropriate decisions that do not maximise benefits in the long term for their organisations. Furthermore, for NHMSs to negotiate effectively and forge beneficial deals with private sector companies there will invariably need to be a shift in their cultures towards more entrepreneurial and business-orientated mind-sets. NHMSs that have gone through such cultural shifts report that the change in culture, and managing 'institutional inertia', invariably takes at least 10 years. For these reasons, it is suggested that the NHMSs take a slow, phased approach to their engagement with the private sector. Such an approach would include detailed assessments of each potential partnership in which risks and rewards are thoroughly quantified before any deals are made. Importantly, the final partnership arrangements would need to be flexible enough to allow the NHMS to engage with a wide variety of private sector partners, to enable the NHMSs to increase their revenue streams in a manner at least proportional to the growth of the national weather market.

The phased approach of engagement with the private sector would comprise a wide range of activities across the NHMSs in the countries supported by the CIRDA programme. This is because the capacity of the different NHMSs to engage with the private sector was found to be highly variable. In some cases, a first phase encompassing revising the regulatory environment, and greatly improving the quality of data generated from the ground observation network as well as basic weather forecasts, would be required. In other cases, there would be scope for the NHMS to immediately start intensive negotiations and discussions with selected private sector companies. The NHMSs in countries supported by the CIRDA programme were categorised – based on extensive interviews with the NHMS staff and other stakeholders working with the NHMS in each country – into three main groups. These groups were: 1) '**Ready to engage with selected private sector companies**' (countries in this group included Tanzania, Zambia and Burkina Faso); 2) '**Moderate capacity building required before extensive engagement with the private sector**' (Benin, Ethiopia, The Gambia, Malawi and Uganda); and 3) '**Intensive capacity building required before extensive engagement with the private sector**' (Liberia, Sao Tome and Principe, and Sierra Leone). The term 'before extensive engagement' is used the names of groups 2 and 3 because even in the group requiring intensive capacity building there are potential private sector opportunities for the NHMSs to start exploring. Sectors that have expressed interest in engaging with the NHMSs in groups 2 and 3 include tourism (in The Gambia and São Tomé), forestry (São Tomé and Príncipe), mining (Liberia and Sierra Leone), and mobile telephone operations (Sierra Leone).

Irrespective of the state of readiness of the NHMSs in countries supported by the CIRDA programme, the first phase of a transition to strong engagement with the private sector would invariably be largely funded from public sources. Substantial private sector funding for the NHMSs could only be expected once the national commercial weather markets have grown and matured.

During the market assessment, numerous activities were identified as potentially appropriate for NHMSs that decide to embark on a slow, phased transition into entities that derive considerable benefits from the national commercial weather market. These activities are summarised below.

Raise awareness. The considerable socio-economic benefits of a well-functioning NHMS should be presented in awareness raising campaigns targeting policymakers in government as well as the general public. Included in this material should be the likely returns derived from investments in the NHMS human resources and infrastructure. The benefits of a thriving commercial weather market should also be quantified. The availability of improved weather products across all economic sectors, for example, can reduce loss of life and damage to infrastructure during extreme weather events, diversify the economy by creating new business opportunities, and consequently increase tax revenues for governments. Conversely, if reliable and timely weather information is only available to those who can pay, a large share of the population in developing countries will be unserved, with detrimental effects on the entire economy.

The overarching objective of the awareness raising campaigns would be greater political support for the NHMSs and ultimately greater investment from government and the private sector. The national treasury would be a particularly important target audience.

Engage with the national treasury. In most countries supported by the CIRDA programme it is likely that revenues generated by the NHMS through engagement with the private sector will be channelled to the national treasury. The budget provided to the NHMS on an annual basis by the national treasury is unlikely to be proportional to the revenues received from NHMS activities. For this funding arrangement to change and benefit/incentivise the NHMSs, national treasuries will need to understand the nature and value of the public goods generated by the NHMSs. This awareness raising should primarily be undertaken internally from the NHMS to national treasury. However, the potential also exists for private sector companies (e.g. mobile telephone companies) that regularly engage with the national treasury to contribute to this awareness raising within national treasuries.

Develop an enabling environment for the private sector. The regulations, policies, and legislation governing the operation of private weather companies and their relationship with NHMSs should be rigorously analysed to determine where revisions would be appropriate. Well-designed regulations that promote data sharing between the NHMS and private weather companies would, for example, be of primary importance for developing the national commercial weather market. It should be noted that legislation that gives sole authority to NHMSs to supply climate and weather information to the public or private sector would not promote the national commercial weather market because it would constrain the operations of many local private weather companies. Such legislation is also unlikely to be enforceable because of the ready availability of climate and weather information from extra-national providers via the internet. Furthermore, such legislation would not be aligned with WMO Resolution 40, which urges members to strengthen their commitment to the free and unrestricted exchange of weather data and products.

Define clear roles for the NHMSs versus the private sector companies. There is the potential for considerable overlap in function between a NHMS and private companies involved in the national commercial weather market. For example, both the NHMS and the companies may be sending out weather alerts to the public, and both may be wanting to receive income from the same weather products (e.g. packages of agro-met information provided to farmers). Such overlap in function is likely to lead to competition and conflict over time between the NHMS and the private sector companies (as was experienced in the USA and The Netherlands). Clearly defining the roles of the public sector NHMS and any private sector entity (including agencies that may have splintered off the NHMS) operating in the national commercial weather market is consequently of fundamental importance.

Expand the ground observation network. The main product that the NHMSs have to offer the private sector is data from their ground observation network of weather stations, and derived products from these data. The value of these data is related to the geographic coverage of the weather stations. In most countries supported by the CIRDA programme, this geographic coverage is very limited, often being from a small number of synoptic stations at airports. Consequently, NHMSs should look for opportunities to expand the coverage of their weather stations, focusing on "local observations" – ones that capture meso- and micro-scale weather events. The WMO is actively encouraging NHMSs to undertake this type of expansion of their ground observation networks; this is because the data that is collected from such expanded networks is of great value for improving the quality of a wide range of weather information products, such as early warnings of extreme weather events, across the country. A particularly promising route for expanding the geographic extent of observations is to build a back-bone network of local observing stations using modern all-in-one automatic weather stations (AWSs) sited at or on mobile phone towers, and then expand out to additional stations in the "cell" served by each tower. The advantages of such sites are the wide geographic spread of the towers, the security of the tower environment, the availability of electrical power, and the continuous capacity of the towers to transmit data. A further advantage is that technicians visiting the towers could potentially undertake the maintenance requirements of the AWSs.

Conduct national market assessments of the potential opportunities for generating revenue from tailored weather information products. This market assessment found a wide range of potential opportunities in terms of future income generation for NHMSs within countries supported by the CIRDA programme. Before an NHMS develops a new product or engages with a private sector partner, detailed research into the particular opportunity would need to be undertaken at a national scale. This market assessment was confined to a continental-scale analysis and consequently did not describe individual national opportunities. Generic opportunities found in this market assessment that could potentially be explored further in national market assessments included the following:

- Partnering with mobile phone companies to disseminate tailored weather information across their networks. NGOs are often engaging directly with mobile phone companies to ensure that important weather information gets across the "Last Mile" to end users. There is invariably scope for the NHMSs to engage with the mobile phone companies and NGOs in such ventures.
- Negotiating partnerships with private companies specialising in provision of primary weather data. It should be noted that such companies do not pay large amounts for historical data (e.g. only ~$500 for a long-term dataset from a particular weather station site). Consequently, the main benefits of partnerships with these companies would be the sharing of revenue streams from products derived from the data, as opposed to the selling of the primary data.
- Developing, with private sector partners, niche weather information products for sale to private clients in the energy, transport, mining, forestry and retail sectors. It should be noted, however, that these products are complex to produce and would probably only be developed in the later phases of the transition of NHMSs to entities engaging strongly with the private sector.
- Expanding the type of weather products produced for the rapidly expanding African aviation sector. The existing contractual arrangements between the NHMS and the aviation sector should also be reviewed to ensure that there is appropriate cost recovery taking place. These arrangements could also be used as a precedent for guiding any new engagement with the private sector (e.g. with mobile telephone companies or private weather data providers).
- Packaging weather information with agronomic information – in collaboration with ministries of agriculture – to sell to farmers.
- Developing tailored weather information products for public sector entities in the following fields: health, water, agriculture, tourism, mining, energy, forestry, fisheries, disaster management, infrastructure and transport.
- Providing highly localised weather information to support the development of weather index-based insurance products. It should, however, be noted that such products will invariably require strong public sector subsidy in the long-term.
- Installing, calibrating and maintaining weather stations – both synoptic and non-synoptic – for private as well as public clients (e.g. other government departments).

Use service providers to bridge the gap between the NHMS and private sector companies. To facilitate appropriate deal-making with private sector companies it is suggested that NHMSs should contract the services of companies that specialise in such negotiations and deal development.

Develop basic in-house private sector expertise to engage with private sector companies. Even if external service providers are used to forge deals with private sector companies, there will still be a requirement for some staff within the NHMSs to have a basic level of understanding of the nature of the private sector in order to objectively assess the costs and benefits of the deals for the NHMS.

For those NHMSs that decide to undertake in-depth national market assessments an important part of the assessment will be to identify suitable entry points into their respective commercial weather markets. It is recommended that the NHMSs initially engage with two different types of private sector companies: firstly those specialising in the provision of weather data, applications, or services; and secondly those with no specific sectoral experience, but which focus primarily on business development, sales and marketing.

The engagement with companies specialising in provision of weather data – in the context of the CIRDA programme – could entail the following steps:

- determine potential revenues for a NHMS from selling primary data at private sector market-related prices;
- determine potential revenues for a NHMS from sharing in revenue streams of private sector tailored weather information products that are derived from the primary data;
- based on the potential revenues above, develop the structure of a deal that would be appropriate – in terms of financial benefits and the national legal framework – for the NHMS; and
- negotiate with private sector companies on the contractual details and ultimately forge a deal.

A first deal forged between an NHMS and a private sector company does not need to be a major commitment for either party. It could be a short-term arrangement. It could have numerous escape clauses that are triggered if the deal does not progress smoothly. It could perhaps limit the exposure of the NHMS by, for example, focusing solely on data generated from equipment purchased through the CIRDA programme. The main benefit of forging such a deal would be the exposure of the NHMS to how the private sector operates and to the vast range of opportunities available within the private sector. It would be a small step forward – with negligible risk – to test a new paradigm of operation for the NHMS in the decades ahead.

**End of report**

# 11. ANNEXURES

## Annexure C5. Status quo of NHMSs

For each country's NHMS, the following points are discussed:

- Mission and mandate
- Medium- and long-term outlook
- Budget and expenditures
- Obstacles

## C5.1 East and southern Africa

### *C5.1.1 Ethiopia*

Mission and mandate

Ethiopia's National Meteorological Services Agency was established as an autonomous government organisation on 31 December 1980[125]. The mission of Ethiopia's National Meteorology Agency (ENMA) is to collect, analyse and study climate data to provide weather forecasts and early warnings on the negative effects of adverse weather events in Ethiopia[126]. To achieve its mission, ENMA has developed the following strategic objectives: i) fulfil national needs and international obligations relating to meteorology; and ii) establish and operate a national network of meteorological stations. In addition, ENMA is mandated with preparing and disseminating Agro-Meteorological Advisory Bulletins to assist planners, decision-makers and farmers. ENMA also produces monthly, seasonal and annual Climate Bulletins and annual Hydro-meteorological Bulletins[127].

The duties and responsibilities of ENMA include:

- Establishing and operating a national network of meteorological stations that include the different climatic regions of Ethiopia;
- collecting all meteorological data;
- exchanging meteorological data in accordance with international agreements;
- establishing and operating a communication system to collect and disseminate meteorological data;
- processing, publishing and disseminating meteorological data and meteorological forecasts;
- providing early warnings for adverse weather conditions;
- supplying advice and educational information on climate and weather without discrimination;
- collecting and archiving any meteorological data collected by any person in the country; and
- controlling air pollution.

Currently, ENMA has over 1,200 conventional weather stations, 25 automated weather stations (AWS), an upper air observation system and automated weather observation systems at Ethiopia's main airports. In addition, ENMA receives satellite images every 15 minutes from the $MSG_2$ satellite launched by the EU. Forecasts generated by ENMA are disseminated through broadcast, print and online media. ENMA also disseminates and exchanges observed data to WMO's member countries[128].

[125] http://blog.intermet.asia/wp-content/uploads/2015/05/Day3-Ethiopia-DulaShanko.pdf. Accessed 7 October 2015
[126] http://www.ethiomet.gov.et/about/mission_vision_value. Accessed 7 October 2015
[127] Federal Democratic Republic of Ethiopia Environmental Protection Authority. 2004. The 3rd National Report on the Implementation of the UNCCD/NAP in Ethiopia. Addis Ababa
[128] Shanko, D. 2012. Use of Automatic Weather Stations in Ethiopia. National Meteorological Agency (NMA), Addis Ababa, Ethiopia.

Through a project implemented by the World Food Programme in 2010, ENMA received 37 AWSs that collect data on environmental variables, including air temperature, rainfall, relative humidity, solar radiation, wind speed and wind direction[129]. These data are transmitted to a central base station every 15 minutes, thereby removing the need for field visits[130]. Forecasts are delivered: i) daily; ii) every three days; iii) every 10 days; iv) monthly; and v) seasonally. In addition, hazardous and extreme weather events are forecast, thereby enabling the population to prepare for the negative effects of hazardous climate and weather events.

Medium- and long-term outlook

Currently, there is no regulatory committee of meteorological services. However, the plan and budget is approved by the government and regularly evaluated by House of People's Representatives' Standing Committee on Natural Resources and Environmental Protection.

The objective of the UNDP-GEF project **Strengthening climate information and early warning systems in Africa for climate resilient development and adaptation to climate change** is to increase the capacity of hydro-meteorological services to monitor and predict weather events and climate change. This objective will be supported in two ways. Firstly, the capacity within ENMA and the Hydrology and Water Quality Directorate to monitor extreme weather events and climate change will be increased. Secondly, hydro-meteorological and environmental information for early warning and long-term adaptation will be improved through improving existing weather infrastructure and adding new weather infrastructure.

This project mentioned above will allow ENMA to produce tailored products for specific sectors by: i) creating an enabling environment for ENMA to produce and use climate and weather forecasts; ii) identifying markets for tailored early warning products; iii) increasing the country's capacity to incorporate climate and weather data into long-term planning and national strategies; iv) creating channels to distribute early warnings to communities; and v) establishing partnerships between the public and private sector to support the financing of early warning and climate information systems.

Medium and long-term meteorological Investment Plan in Ethiopia (2016–2025)

Ethiopia has formulated an investment plan for the period 2016–2025. This plan highlights the following eight investment objectives: i) expansion and modernisation of observational stations; ii) communication, interpretation and dissemination of climate and weather information; iii) modernisation of computer equipment; iv) increased capacity of ENMA staff; v) modernisation of infrastructure and equipment within the ENMA office; vi) improved meteorological services for specific sectors; vii) medium- and long-term climate predictions; and viii) modernisation of equipment, including inspection, maintenance and improvement of weather station apparatus[131].

[129] Shanko, D. 2012. Use of Automatic Weather Stations in Ethiopia. National Meteorological Agency (NMA), Addis Ababa, Ethiopia.
[130] Shanko, D. 2012. Use of Automatic Weather Stations in Ethiopia. National Meteorological Agency (NMA), Addis Ababa, Ethiopia.
[131] Shanko, D. 2012. Use of Automatic Weather Stations in Ethiopia. National Meteorological Agency (NMA), Addis Ababa, Ethiopia.

Budget and expenditures

The revenue generated for ENMA through the sale of products and services will increase with the increased user awareness of the benefit of climate and weather information. In particular, the insurance sector needs weather data to appraise insurance claims made by smallholder farmers. However, the current recovery fee does not cover the cost of providing the service.

Public-private partnerships (PPPs)

Private companies that install meteorological stations are legally required to share the data that is collected with ENMA. However, this law is rarely enforced, thereby limiting the extent to which privately collected weather data is shared with ENMA. Investment in ENMA by the private sector could increase the density of the meteorological observation network.

Obstacles

Currently, ENMA's observational and analytical capacity is limited, resulting in incomplete forecasts, which prevents optimal responses to extreme weather events. Consequently, the negative effects of climate-related hazards on a range of sectors – including food, water, and energy – is exacerbated[132]. The limited capacity within ENMA is attributed to the following obstacles:

- Limited geographical coverage of the national meteorological station network;
- limited budget for managing and administering station network;
- insufficient capacity and budget to maintain and expand the national meteorological; station network;
- inadequate channels to communicate climate and weather data;
- limited technical capacity of ENMA staff;
- limited awareness of modern technology within ENMA;
- inefficient connectivity between head and branch offices;
- gaps in meteorological data;
- faulty equipment and slow maintenance services, with limited budget to improve; instruments and provide training to staff;
- limited digitisation of historical climatological data; and
- limited capacity to provide meteorological forecasts for both the aviation and development sectors[133].

In addition, there are numerous limitations associated with establishing and maintaining AWS in Ethiopia. These limitations include: i) malfunctioning AWS as a result of irregular inspection schedules; ii) reliance on poorly functioning internet connections to receive data from AWS; iii) limited technical capacity in calibrating AWS equipment; iv) limited expertise and facilities to maintain AWS; v) inadequate training periods for new staff; vi) limited availability of spare parts for the maintenance of AWS; and vii) limited life-span of AWS and limited budget to reinvest in equipment[134].

[132] Federal Democratic Republic of Ethiopia Environmental Protection Authority. 2004. The 3rd National Report on the Implementation of the UNCCD/NAP in Ethiopia. Addis Ababa
[133] Shanko, D. 2012. Use of Automatic Weather Stations in Ethiopia. National Meteorological Agency (NMA), Addis Ababa, Ethiopia.
[134] Federal Democratic Republic of Ethiopia Environmental Protection Authority. 2004. The 3rd National Report on the Implementation of the UNCCD/NAP in Ethiopia. Addis Ababa

*C5.1.2 Malawi*

Mission and mandate

Malawi's NHMS (M-NHMS) is administered by the Department of Climate Change and Meteorological Services under the Ministry of Natural Resources, Energy and Mining.

The M-NHMS is mandated with monitoring, predicting and providing information on weather. By providing these services, the M-NHMS supports a national response to climate change, in particular the promotion of socio-economic development. The weather services that M-NHMS provides is available to all socio-economic sectors at local, national and regional levels[135]. The mission of the M-NHMS is to provide climate services to fulfil national, regional and international obligations through the dissemination of accurate and timely weather data and information[136].

To achieve its mission, M-NHMS has developed the following strategic objectives:

- Monitor, analyse and predict climate and weather information to produce early warnings for hazardous weather events.
- Provide climate and weather information to various socio-economic sectors such as aviation, agriculture, water, construction, insurance, tourism, and sports and recreation.
- Conduct research to improve the quality of climate and weather information for the general public to be disseminated through mass media.
- Establish and maintain a network of meteorological stations to ensure that data and information is reliable, timely and up-to-date.

Malawi is a member of WMO and therefore follows WMO standards for meteorological observation[137]. Currently, Malawi has 22 meteorological stations, 21 subsidiary agrometeorological stations and over 400 rainfall stations[138]. At the meteorological stations, weather observations are made seven times a day during the week, and twice a day on weekends by trained Meteorological Assistants[139]. This weather data is disseminated via radio, television, website, emails, and text messages.

**Table C5.1.** NHMS sector and service information[140].

| Sector | Service |
|---|---|
| Aviation | • Weather information for take-off and landing;<br>• aircraft route forecast; and<br>• aerodrome forecast. |
| Aquatic | Early warnings provided over Lake Malawi |
| Agriculture | • Irrigation;<br>• crop protection;<br>• crop insurance;<br>• crop management;<br>• EWS for food security; and<br>• climate risk management. |
| Water Resources | • The design of dams; and<br>• EWS for floods and droughts. |

[135] http://unfccc.int/resource/docs/natc/mwinc2.pdf. Accessed 27 September 2015.
[136] http://www.metmalawi.com/weather/stations.php. Accessed 27 September 2015.
[137] http://unfccc.int/resource/docs/natc/mwinc2.pdf. Accessed 27 September 2015.
[138] http://www.metmalawi.com/weather/stations.php. Accessed 27 September 2015.
[139] http://www.metmalawi.com/weather/stations.php. Accessed 27 September 2015.
[140] http://www.metmalawi.com/weather/stations.php. Accessed 27 September 2015.

| | |
|---|---|
| Energy | • Hydropower;<br>• wind energy; and<br>• solar energy. |
| Building and Construction | • Road construction; and<br>• building construction. |
| Retail | Weather information for marketing strategies |
| Legal | Evidence provided in courts for weather-related cases |
| Environment | Climate change information |
| Fishing | Climate and weather information for fishing strategies |
| Road and Railway Transport | Climate and weather information to inform road or railway line usage. |
| Sport and Recreation | • Forecasts for yachting; and<br>• forecasts for soccer matches. |
| Health | • Weather and information for the prediction of disease outbreaks and planning; and<br>• meteorological information for research. |
| Disaster Preparedness | • Tropical cyclone warnings;<br>• early warnings; and<br>• flood forecasts. |
| Banking | Weather/climate forecasts for agricultural loans |
| Public | • Short-range weather forecasts;<br>• Medium-range weather forecasts; and<br>• seasonal forecasts. |

Medium- and long-term outlook

To improve the M-NHMS in Malawi, there is a pressing need to implement the following projects: i) Modernization of Meteorological Services; and ii) Climate Change and Meteorological Capacity Development. However, limited funding has prevented these projects from being realised[141].

The UNDP-GEF project **Strengthening climate information and early warning systems in Africa for climate resilient development and adaptation to climate change** seeks to strengthen Malawi's weather, climate and hydrological monitoring capabilities, EWSs and the delivery of available information to facilitate adaptation planning and timely responses to extreme weather. To achieve this objective, the project will improve meteorological equipment and increase the capacity of the NHMS staff. In particular, the outcomes of the project include: i) improving the capacity of the Department for Climate Change and Meteorological Services and the Department for Water Resources to monitor and forecast extreme weather and climate change; and ii) efficiently and effectively use hydro-meteorological and environment-related information support EWS and the design long-term development plans. Through these outcomes, the project is expected to reduce food insecurity and vulnerability to climate change in Malawi. In particular, the establishment of a network of automated weather stations will facilitate effective early warnings, thereby enabling small-scale farmers, business owners and vulnerable communities to prepare for hazardous climate events.

Budget and expenditures

To increase demand – and therefore revenue generation – from the private sector, the M-NHMS should: i) improve awareness of its products and services; ii) improve the quality and resolution of the information that is generated; and iii) engage with the users to tailor products and services to their specific needs. In addition, if the accuracy and reliability of climate services were to be improved, additional revenue could be generated for the NHMS through the provision of products and services that include: i) climatological

[141] http://www.wmo.int/pages/prog/wcp/wcdmp/documents/Malawi.pdf. Accessed 27 September 2015.

data; ii) climatological summaries; iii) agro-meteorological products; iv) weather reports for insurance claims; v) calibration of equipment for other institutions; vi) equipment hire; vii) training of weather observers from other institutions.

Public-private partnerships (PPPs)

Currently, there is competition between the NHMS and private weather companies as a large percentage of the population use private online sources for climate and weather information, instead of the NHMS.

Malawi has created an enabling environment for PPPs though policies and the Public-Private Partnership Bill (2010), the latter of which facilitated the establishment of a dedicated PPP unit in Malawi, i.e. the Public-Private Partnership Commission.

There is potential for collaboration with the private sector to improve the products and services offered by the NHMS. For example, the private sector can assist with adding value to the NHMS's products and services, as well as improve communication channels for climate information. In addition, since some private sector organisations own and operate their own meteorological stations, there is scope for sharing of data. Indeed, many private sector organisations are open to working the government as they already provide some services to the government.

Obstacles

Obstacles to the NHMS's development include:

- An absence of a meteorology-specific Act;
- limited budget, resulting in a shortage of modern equipment for the improvement of information, products and services;
- limited availability of trained staff;
- inadequate technological and marketing capacity to tailor products and services to the public and private sector[142];
- limited research and systematic observation activities[143];
- inadequate forecasting, post-processing of climate data; and
- limited infrastructure to calibrate climate-monitoring apparatus and manage climate databases[144].

*C5.1.3 Tanzania*

Mission and mandate

Tanzania Meteorological Agency (TMA) has been autonomous since 1997, and is the sole provider of meteorological information in Tanzania. The mission of TMA is to contribute to the protection of life and property, as well as contribute to the national goal of reducing poverty[145].

The TMA's functions are to:

- Provide meteorological services for international air navigation on behalf of the United Republic of Tanzania;
- implement and administer an effective network of surface and upper air stations to capture and archive data on climate and weather conditions;
- participate in the global exchange of meteorological and climate data and products to promote safety and to enhance the understanding of the global atmosphere;
- provide weather, climate services and early warnings to promote the safety and property of the population, as well as sectors such as aviation, agriculture and food security, water resources, disaster management, health and construction;

[142] http://www.wmo.int/pages/prog/wcp/wcdmp/documents/Malawi.pdf. Accessed 21 September 2015.
[143] http://unfccc.int/resource/docs/natc/mwinc2.pdf. Accessed 21 September 2015.
[144] URoT. 2012. Regional infrastructure development master plan, meteorology sector plan.
[145] http://www.meteo.go.tz/store/service.pdf. Accessed 21 September 2015.

- conduct research and training in meteorology and climatology, as well as collaborate with other institutions to promote socio-economic development planning;
- cooperate with institutions concerned with climate variability, climate change and environment; and
- perform any additional function as the Minister may direct.

**Table C5.2.** Current and required meteorological observational stations network[146].

| Description | Number of stations | | | |
|---|---|---|---|---|
| | Current | Operational | Required | Shortage |
| Conventional Surface synoptic stations | 26 | 26 | 32 | 6 |
| AWS Surface synoptic stations | 14 | 5 | 113 | 108 |
| Agrometeorological stations | 15 | 15 | 20 | 5 |
| Ordinary climate stations | 150 | 60 | 250 | 100 |
| Rainfall stations | 2,056 | 500 | 500 | 0 |
| Automatic Rainfall stations | 0 | 0 | 2,500 | 2,500 |
| Marine weather station | 0 | 0 | 12 | 12 |
| Upper air stations | 1 | 1 | 4 | 3 |
| Pilot Balloon | 1 | 0 | 5 | 5 |
| Weather Radar | 1 | 0 | 7 | 6 |
| Lightning | 0 | 0 | 10 | 10 |
| Orbiting satellite receiver | 0 | 0 | 1 | 1 |

**Table C5.3** Products and services provided by TMA.

| Products and Services | Delivered |
|---|---|
| Weather forecasts | Daily through radio broadcasts, television broadcasts, telephone, email, fax, face-to-face and via TMA website. |
| Prospects/Weather forecast | Every 10 days, monthly and seasonal |
| Severe weather warning for strong winds, cyclones, hurricanes, tornadoes, drought and floods | Occasionally |
| Aviation forecasts | Not specified |
| Sea and lake forecasts | Not specified |

Medium- and long-term outlook

The UNDP-GEF project **Strengthening climate information and early warning systems** aims to strengthen the capacity of both national and sub-national authorities to monitor climate change, generate reliable hydro-meteorological data, produce early warnings and compare this information with other environmental and socio-economic data to improve evidence-based decision-making. To support this aim, the project will: i) invest in upgrading weather, climate, hydrological and environment monitoring infrastructure; and ii) integrate climate and weather information into development plans and early warning systems. Through this project's interventions – in particular, improving early warnings – damage to physical infrastructure and agricultural land, and the disruption of livelihoods will be decreased.

The **Five-year plan for enhancement of meteorological services for sustainable socio-economic development in Tanzania** aims to improve the country's meteorological services, through the following objectives: i) strengthening the Meteorological Observing

[146] URoT. 2011. Enhancement of met service, final report.

Network; ii) upgrading telecommunication systems; iii) enhancing data processing and forecasting systems; iv) upgrading data management capability in the TMA.

To support these objectives, the plan will promote: i) expanded presence of surface, upper air observation network and radar network; ii) enhanced computing facilities; iii) improved telecommunication systems for national, regional and global data exchange; and iv) improved forecasting through the development of numerical weather prediction techniques. The plan also highlights the need for human resources capacity building, especially in numerical modelling skills, installation and maintenance of instruments and equipment.

Budget and expenditures

TMA generates income from the private sector through the delivery of services. However, there is no recovery of cost from these services. In addition, products and services provided to the aviation and marine sectors have fixed prices, but these prices are not reflective of the value of the product. TMA's resource requirements are therefore supplemented by government subsidies, loans and grants (East African Community, 2004). In particular, during the 2013/2014 fiscal year, TMA had a budget of ~TZS 5.5 billion, ~75% of which was generated from internal sources, including: i) ~22% from landing and parking charges; ii) ~50% from Air Navigation; iii) ~1.5% from charges for meteorological data and products; iv) 0.02% from training activities and programs fees; v) 0.1% from consultancy and education tour charges; and vi) 0.5% for providing NHMS to the media.

**Table C5.4.** Generation of revenue for TMA during the period 2014–2015.

| Description | Draft Estimates (TZS) |
|---|---|
| Landing and Parking charges | 1,540,098,000 |
| Air Navigation | 3,754,000,000 |
| Charges for meteorological data and products | 82,936,000 |
| Fees from training activities and programs | 11,267,000 |
| Charges from consultancy and education tours | 6,780,000 |
| Fees from NHMS to media | 5,965,000 |
| **TOTAL** | **5,401,046,000** |

Public-private partnerships (PPPs)

Currently, TMA has limited interaction with the private sector. However, there is a national strategy under development for the exchange of climate and weather information. To promote demand for this information by the private sector, TMA needs to improve the quality and variety of the products and services that they offer. PPPs will increase the income generated by TMA, thereby enabling TMA to improve their outputs and enhance the effectiveness of their communication. In addition to partnerships with economic sectors – particularly agriculture, health, marine, energy, mining, aviation, tourism and wildlife management, natural disaster management and construction – there is also potential for PPPs in Tanzania with *inter alia*: i) NGOs; ii) mobile phone companies; iii) the Telecommunication Regulation Authority; and iv) Beach Management.

There is an existing legal framework for PPPs in Tanzania, as well as a dedicated PPP unit in the country (Tanzania Investment Centre). To monetize the provisioning of accurate and timely weather information, policies and strategies would need to be revised to promote the development of service agreements and a Meteorology Act.

Obstacles

Obstacles to the NHMS's development include:

- A limited number of meteorological and hydrological observation stations;
- ineffective channels to communicate weather, climate and early warning information;
- a limited number of real-time data processing facilities;
- the technical complexity associated with monitoring and forecasting erratic tropical weather;
- an absence of a National Meteorological Centre building, which prevents investment and installations of communication infrastructure;
- ineffective recruitment and training of staff, coupled with regular staff turnover;
- inadequate budget to support the operational management of meteorological services; and
- inadequate Internet bandwidth and computing facilities.

*C5.1.4 Uganda*

Mission and mandate

Uganda's National Meteorological Authority (UNMA, formerly Department of Meteorology) is a semi-autonomous government division that falls under the Ministry of Water and Environment.

UNMA is mandated with monitoring climate and weather, as well as providing weather forecasts and advice to government agencies and other stakeholders to promote sustainable development within the country[147]. UNMA is also legally required to provide meteorological services to the aviation sector. The mission of UNMA is to contribute to national development in Uganda through the provision of accurate, cost-effective and timely information on climate and weather to all users[148]. In addition, UNMA is the focal institution to the Inter-Governmental Panel on Climate Change (IPCC).

To achieve its mission, UNMA has developed the following strategic objectives:

- Strengthen the observation network by improving the distribution and capacity of meteorological services;
- develop a skilled and motivated workforce by investing in human resource management;
- promote greater awareness in the public and private sectors of the benefits of using meteorological services and information products;
- improve the accuracy and reliability of forecasts and advisory services to customers by increasing UNMA's capacity for delivering climate predictions and short-term weather forecasts; and
- increase revenues from the private sector to facilitate implementation strategic objectives.

As of 2012, Uganda had 12 synoptic stations, 18 agro-meteorological stations and 110 rainfall stations – of which only 60 are active[149]. Information on climate and weather generated by the NMA is valuable to a variety of sectors in Uganda, including: i) agriculture; ii) livestock development and food security; iii) transport; iv) health and public safety; v) building and construction; vi) disaster management; and vii) water resources management[150].

[147] https://www.wmo.int/pages/prog/amp/pwsp/documents/Nkalubo_Uganda_2.pdf. Accessed 3 September 2015.
[148] http://www.unma.go.ug Accessed 3 September 2015.
[149] http://www.unma.go.ug Accessed 3 September 2015.
[150] GoU. 2012. Uganda's fiver-year meteorological development plan and investment strategy.

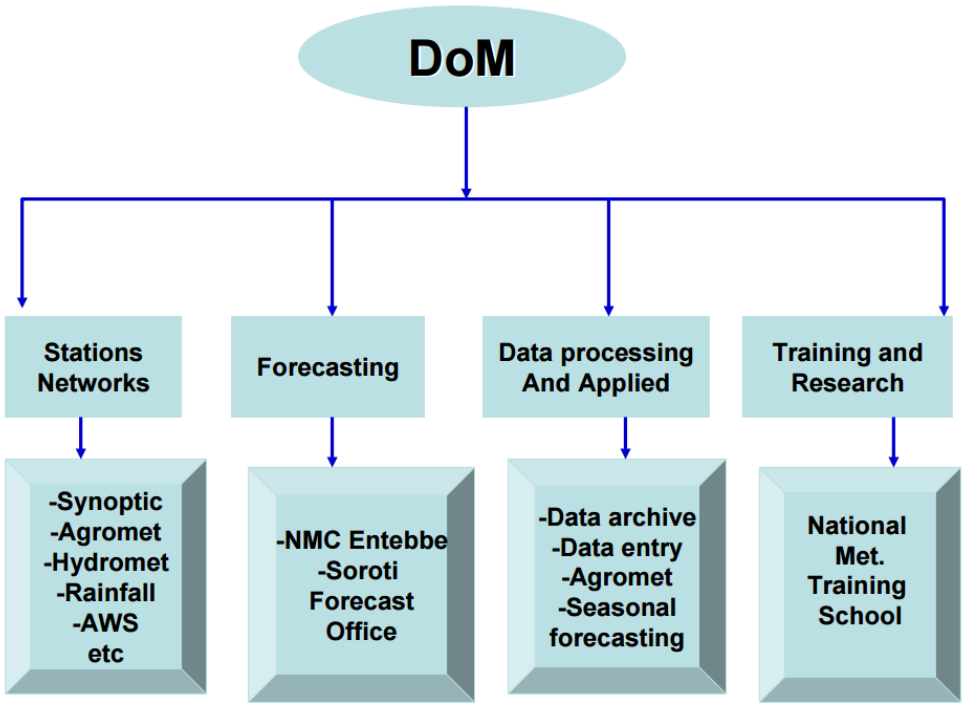


**Figure 11.2.** Conceptual diagram showing the services provided by the Department of Meteorology[151].

Medium- and long-term outlook

The **UNMA Act** of 2012 provides UNMA with the legal framework to market its products and services, thereby allowing meteorological information to be sold for profit. This additional revenue can be used to improve the products and services offered by UNMA.

UNMA is implementing a **Modernisation Programme** that will replace the current analogue weather-monitoring equipment with AWSs that transmit data in real time to the National Meteorological Centre in Entebbe. In addition, the modernisation programme will support the installation of radiosondes, lightning detection systems, S-band Doppler radars and low-level windshear alert systems. Through the modernisation programme, the capacity of UNMA to generate and disseminate accurate and timely climate and weather data will increase.

The Government of Uganda – as well as international donors – will provide the initial US$21.5 million investment that is required to support UNMA's modernisation programme. An additional US$25 million will be necessary to cover the costs of maintaining and operating the equipment and the costs of associated training programmes. While these investment costs are considerable, there is potential for economic benefits by: i) reducing losses through early warnings of extreme weather events, thereby allowing people to move their belongings and livestock to safe areas; ii) increasing the competitive advantage of businesses by enabling weather-induced changes in demand to be anticipated; and iii) improving agro-meteorological advice to farmers, thereby their strengthening their resilience to climate change.

The primary focus of the modernisation programme will be to develop EWSs, and in particular, improve the accuracy of weather predictions. Currently, there are no early warnings in Uganda for floods, flash floods or landslides, and little meteorological information available for EWSs related to other hazards. The modernisation programme will address these information gaps by issuing accurate

[151] https://www.wmo.int/pages/prog/amp/pwsp/documents/Nkalubo_Uganda_2.pdf. Accessed 3 September 2015.
[151] https://www.wmo.int/pages/prog/amp/pwsp/documents/Nkalubo_Uganda_2.pdf. Accessed 3 September 2015.

early warnings that are informed by data generated from reliable equipment. Consequently, trust in climate and weather information products and services from UNMA will increase. This will allow UNMA to enhance its provision of services beyond the aviation industry.

While the public are legally entitled to weather forecasts and early warnings, improved equipment established through the modernisation programme will increase the capacity of UNMA to create tailor-made, sector-specific products that can be developed and distributed for profit. The UNMA Act (2012) created the enabling environment for this revenue generation, as it provides UNMA with the legal authority to market climate and weather information products and services. This is likely to decrease the dependency of UNMA on government funding by increasing the generation of revenue from sectors that require weather information. To illustrate this potential, Uganda's economy is dominated by the agricultural sector, which employs ~82% of the workforce and contributes ~44% to national GDP[152]. Considering that crop success is largely dependent on weather, and that traditional knowledge of farmers in anticipating weather events is likely to become obsolete with climate change, there is great potential for the agriculture sector to pay for services generated by UNMA.

The UNDP-GEF project **Strengthening climate information and early warning systems in Africa for climate resilient development and adaptation to climate change** seeks to strengthen the weather, climate and hydrological monitoring capabilities, early warning systems and available information for responding to extreme weather and planning adaptation to climate change in Uganda. To achieve this objective, the project will install 16 AWS, 40 manual hydrometeorology stations and rehabilitate five AWS. In addition, through the project interventions, the technical capacity of the UNMA to monitor and forecast extreme weather, hydrology and climate change will be increased.

**MTN Uganda** – in partnership with UNMA, WMO, MTN, Ericsson, National Lake Rescue Institute and the Kalangala Fishing community – established a pilot project with the objective of providing localised weather alert services to fishing villages on Lake Victoria[153]. Through this project, 19 representatives from fishing communities were trained on basic interpretation of weather forecasts and appropriate responses to various alerts that were received via mobile phones[154]. Similarly, rural communities could request forecast information from UNMA by texting a hotline. The revenue generated from sending these forecasts – at US$0.5 per message – was divided among UNMA and MTN.

Budget and expenditures

UNMA is funded by government. However, supplementary sources of funding are provided by external agencies, including UNDP, GIZ and USAID. UNMA's funds are used to support system upgrades and capacity building. In addition, since the 1990s, UNMA has had a cost recovery agreement with Uganda's Civil Aviation Authority (CAA). Through this agreement, monthly payments are made to the national Treasury, although this agreement needs to be renegotiated to account for inflation and equipment costs[155]. With the implementation of UNMA's modernisation programme – and consequently the development of improved products and services – an updated costing structure is being proposed. This new costing structure represents the actual cost of providing meteorological information to the aviation sector.

The modernisation programme will require financial adjustments from the Government of Uganda. These adjustments should increase the availability of funds that promote the development of EWSs, which will support UNMA's efforts to convert AWS data into information products. These information products can then be used for commercial profit, thereby reducing UNMA's dependency on government funding.

Public-private partnerships (PPPs)

[152] http://www.nationsencyclopedia.com/economies/Africa/Uganda-AGRICULTURE.html. Accessed 13 August 2015.
[153] http://pressoffice.mg.co.za/mtn/PressRelease.php?StoryID=229741. Accessed 3 September 2015.
[154] http://pressoffice.mg.co.za/mtn/PressRelease.php?StoryID=229741. Accessed 3 September 2015.
[155] https://www.wmo.int/pages/prog/amp/pwsp/documents/Nkalubo_Uganda_2.pdf. Accessed 3 September 2015.

By legislation, UNMA is the sole climate information provider and therefore does not experience competition with private weather companies, although several organisations produce their own data – such as the Ministry of Agriculture and national universities, as well as sugar and tea plantations. However, since the AWS equipment used to generate these data is not synoptic and therefore does not comply with WMO standards, there is limited opportunity to share these data with the UNMA. When private companies want to generate their own data, UNMA installs AWS stations to ensure there is consistency with international standards. Insurance and telecom organisations have expressed an interest in using UNM to install AWS stations on their behalf. Indeed, private sector demand for weather services has increased in response to climate change. This increase in demand can be used to tailor the services currently provided by UNMA to the private sector.

The Private Sector Foundation was established by the Government of Uganda to promote PPPs. This foundation allows the private sector to engage with the public sector and UNMA by facilitating negotiations for partnerships opportunities. Through these partnerships, NHMS products can be tailored accordingly. If the formation of PPPs is supported, it will increase the UNMA's client base and therefore, UNMA's revenue.

Obstacles

UNMA is currently experiencing considerable demand for timely and accurate climate information, products and services. However, the NHMS in Uganda faces several obstacles in achieving their mission and mandate, including:

- Understaffing – the number of people leaving NMA through retirement exceeds the number of new recruits;
- funding – limited financial support to the NMA has resulted in the deterioration of the network of field observing stations and a decrease in inspection of stations. In addition, mobilising funds to implement the modernisation strategy has been delayed;
- equipment – observation instruments are outdated;
- limited institutional capacity – the institutional framework for climate change coordination within UNMA and the GoU has hindered the implementation of some interventions; and
- limited technical capacity – there is a shortage of specialised meteorological training institutions in Uganda, which has necessitated costly international training courses for UNMA staff.

Several of these issues – in particular, limited technical capacity and inadequate equipment for forecasting – are being addressed by the modernisation programme, as well as the UNDP-GEF project 'Strengthening climate information and early warning systems in Africa for climate resilient development and adaptation to climate change'.

*C5.1.5 Zambia*

Mission and mandate

The National Meteorological Service in Zambia (ZNMA) is a specialised agency under the Ministry of Transport, Works, Supply and Communications (MoTWSC).

ZNMA is the main provider of meteorological services to the public and private sector. ZNMA is mandated with observing, analysing and predicting climate and weather information to: i) protect life and property; ii) safeguard the environment; iii) provide advice for policy development; and iv) contribute to sustainable development. The mission of ZNMA is to monitor, predict and provide reliable, timely, accurate and user-friendly climate services for sustainable socio-economic development through collaboration with stakeholders[156]. To achieve its mission, ZNMA has the following responsibilities and functions[157]:

- Establish and maintain a network of observational surface and upper air stations.

[156] http://www.mtwsc.gov.zm/?option=com_content&view=article&id=118:zambia-meteorological-department&catid=57:departments&Itemid=1021 Accessed 15 September 2015.
[157] http://www.mtwsc.gov.zm/?option=com_content&view=article&id=118:zambia-meteorological-department&catid=57:departments&Itemid=1021 Accessed 15 September 2015.

- Establish a telecommunication system to collect and disseminate meteorological data and products for national and international use, in compliance with the regulations stipulated by WMO.
- Process and analyse meteorological data to promote economic development.
- Provide meteorological services to Civil Aviation in accordance with the International Civil Aviation Organisation (ICAO) guidelines.
- Provide Meteorological Information Service to Government Departments, Public Corporations and the general population.
- Provide meteorological services to promote the development of agriculture, water resources and other weather-sensitive economic sectors.
- Conduct research in meteorology and cooperate with organisations concerned with meteorological research and applications.
- Participate in activities that are aligned with international regulations, particularly those outlined by WMO.

**Table C6.5.** Products and services offered by ZNMA[158].

| Products and Services | Sector | Delivered |
|---|---|---|
| Seasonal rainfall forecast | Agriculture; Insurance, commerce and Industry; Health | September or October |
| Weekly weather forecast | All | Monday and Fridays |
| Evening weather forecast | Agriculture; Energy and Water Development | Daily |
| Televised weather report and forecast | Public | Monday, Wednesday and Fridays |
| 6-monthly rain forecasts | Agriculture; Energy and Water Development | Every 6 months |
| Weather bulletin for crop farmers | Agriculture | Every 10 days |
| Aviation forecasts<br>• Area and route forecasts;<br>• Aerodrome forecasts<br>• Landing and take-off forecasts<br>• Aerodrome and wind-shear warnings;<br>• Meteorological aviation reports | Transport | Daily |
| Severe weather warnings for tropical cyclones, thunderstorms, strong winds, extreme cold conditions, drought and floods | All | Occasional |
| Technical reports or publications | All | Occasional |
| Climate Databank Service | All | Data supplied on request |

In 2013, Zambia had 41 weather stations that were sparsely distributed, i.e. in only 30 out of 100 districts. Less than half of the stations are operational at any one time as a result of outdated equipment. There are 10 professional staff (tertiary degree holders) and 170 technical staff (diploma/certificate holders). Despite limited technical and technological capacity, the demand for meteorological products and services by economic sectors in Zambia has increased.

Medium- and long-term outlook

Currently, the effective operation of the meteorological sector in Zambia is hindered by limited policy on meteorology, poor maintenance of equipment, deteriorating observation infrastructure and a shortage of technical staff. The medium and long-term outlook of ZNMA seeks to address these limitations.

[158] http://www.mtwsc.gov.zm/?option=com_content&view=article&id=118:zambia-meteorological-department&catid=57:departments&Itemid=1021 Accessed 15 September 2015.

The UNDP project **Strengthening climate information and early warning systems in Africa for climate resilient development and adaptation to climate change** aims to strengthen ZNMA's capacity to produce climate information and Early Warning Systems (EWS). While these systems are operational in Zambia, limited coordination between institutions has reduced the efficiency at which climate information and warnings are packaged and disseminated. These problems are exacerbated by inadequate infrastructure and equipment, as well as limited technical capacity. The objective of this project is therefore to strengthen Zambia's climate monitoring capabilities and EWS while improving the information available to respond to weather shocks and adapt to climate change. This objective will be supported through two components. Firstly, climate and environmental monitoring will be enhanced through the installation of 28 AWSs, the repair and maintenance of the existing 41 manual and Automatic Weather Stations and increased technical capacity of staff within ZNMA. Secondly, climate information will be integrated into development plans and early warning systems by tailoring sector-specific climate and weather information to the public and private sector decision makers, civil society, development partners and local communities. In addition, innovative channels to issue early warnings will be developed, including mobile phone-based alert platforms.

The National Meteorology Policy[159] is the primary legislation that promotes the integration of climate and weather information into national development plans. The aim of Zamia's NMP is to implement appropriate strategies and develop the legal and institutional framework to support the sustainability of ZNMA, largely through cost recovery on selected products and services. In addition, the policy aims to strengthen linkages with other sectors to facilitate regional cooperation and compliance with international meteorological commitments. These aims are supported by the following objectives: i) establish an optimal network of stations for meteorological, hydrological and other geophysical observations; ii) achieve international standards in the practice and application of meteorology; iii) optimise the use of information communication technology (ICT) in climate services; and iv) enhance the participation of women in the provision and use of climate services.

Through the Meteorological Bill (2015), it is proposed that ZNMA be permitted to introduce marketable products and services, enabling it to generate the finance needed to improve and expand its operations[160.] This will include[161]:

- Providing for the governance of the Zambia Meteorological Department and clarifying its statutory functions;
- providing meteorological services for the benefit of all sectors – including agriculture, tourism, military aviation, surface and marine transport, industry, commerce, insurance and management of energy and water resources – to contribute to sustainable socio-economic development;
- ensuring the application of international standards and practices in meteorology;
- regulating the establishment of meteorological stations, upper air stations, meteorological station networks and meteorological telecommunication systems;
- promoting the use of information communication technologies to effectively generate and disseminate climate and weather information and data;
- providing public good services and commercial services;
- maintaining a National Climate Data Bank; and
- providing weather bulletins, early warning services and other weather warnings.

Budget and expenditures

The Government provides funding to MoTWSC, which then distributes the funds to each of its 10 departments. When there is an urgent need for an increase in funding to cover additional costs, MoTWSC will reallocate money from other departments. Approximately 90% of ZNMA's budget is provided by government, with being derived from non-governmental organisations[162].

ZNMA's budget is divided into three broad components: i) salaries, which increase over time; ii) recurrent department charges, which remain largely constant; and iii) capital, including infrastructure and equipment, which often decreases. Currently, there is limited capacity in ZNMA to quantify the products and services provided to various socio-economic sectors. Indeed, the legislative

[159] NMP, 2013
[160] http://www.undp-alm.org/sites/default/files/downloads/ciews_zambia_ppt_for_cirda_ppp_workshop.pdf. Accessed 6 September 2015.
[161] This text is extracted from the Meteorological Bill (2015).
[162] https://www.wmo.int/cpdb/dashboard/zambia. Accessed 6 September 2015.

environment does not enable ZNMA to participate in commercial activities as it is considered a state-owned agency, whose outputs are for national and public use only[163]. However, there is potential in Zambia to generate revenue by providing climate-related services to the following sectors[164]:

- The aviation sector is greatly dependent on accurate and reliable weather information to promote the safety, efficiency and regularity of flight operations. However, ZNMA does not generate additional revenue from the aviation sector because payment for the provision of weather services is made to the National Airport Corporation.
- ZNMA issues a seasonal rainfall forecast for the agricultural sector to inform farmers of the timing and nature of rains for the coming season. These forecasts are used by farmers to inform them of the most appropriate date to plant crops, as well as the best cropping strategies and tillage practices. In addition, the crop-weather bulletin provides farmers with information that allows them to track rainfall patterns.
- City planning of water resources management is often reliant on rainfall data. For example, the design of drainage system depends on rainfall intensity. In addition, ZNMA provides meteorological information to Zambia Electricity Supply Corporation to assist with the planning of electric power generation.
- The production of maps for education and research incorporates weather variables that can be used in by planners, educators and scientists.
- Early warnings can considerably reduce the negative health effects of extreme weather events on the population of Zambia. The health sector benefits from early warnings by allowing authorities to stockpile medication and contain the outbreak of disease.
- Within the building and civil engineering sector, knowledge of weather variables – including *inter alia* wind, temperature and rainfall – are essential in the design of infrastructure.

Public-private Partnerships

Legislation in Zambia prevents private sector companies with providing NHMS data. However, there are mining companies and individuals that generate climate information from their own AWSs, but these data are not for public use.

There is a draft law for the NHMS to charge for the services they deliver. In addition, The Meteorological Bill (2015) makes provisions to encourage and facilitate public-private partnerships in the development of meteorological services.

Obstacles

Obstacles to developing ZNMA include:

- Limited channels for the dissemination of information on climate and weather conditions[165];
- shortage of qualified meteorological staff and local consultants, as well as regular staff turnover within ZNMA;
- limited community engagement during the rainy season;
- limited ICT access and/or transport to obtain data from manual rainfall stations;
- absence of specialised branches of meteorology (e.g. marine meteorology) to provide sector-specific services;
- limited distribution of observation stations;
- outdated equipment and irregular instrument repair, maintenance and calibration;
- inadequate facilities for effective data processing, archiving and dissemination; and
- limited number of weather parameters being monitored[166].

## C5.2 West Africa

[163] https://www.wmo.int/cpdb/dashboard/zambia. Accessed 6 September 2015.
[164] http://www.mtwsc.gov.zm/?option=com_content&view=article&id=118:zambia-meteorological-department&catid=57:departments&Itemid=1021. Accessed 6 September 2015.
[165] https://www.lusakatimes.com/2012/11/05/meteorological-department-challenged-improve-communication. Accessed 6 September 2015.
[166] Zambia's National Meteorological Policy 2013.

*C5.2.1 Benin*

Mission and mandate

Benin's Meteorological Agency (BMA) is the sole provider of climate and weather information in the country, and aims to become a semi-autonomous institute in 2016. There are regulations that enable BMA to sell data, however, the income generated from these sales do not cover the costs of providing this information. To address these financial limitations, a decree to strengthen the commercial activities of BMA has been signed.

BMA provides seasonal forecasts at three regional levels: the Sahel, the Gulf of Guinea and West Africa. Currently, channels for disseminating this information to farmers are being explored in collaboration with local universities, NGOs and extension workers. This is particularly challenging in Benin as there are 50 languages in the country, suggesting that the communication of weather information – which is broadcast through community radio and television – will be a complex task. In addition, farmers often face difficulties in interpreting the information that BMA provides. To address these challenges, the Ministry of Agriculture is in discussions with local farmers to determine the preferred format for receiving weather information.

Approximately 90% of BMA's budget is derived from providing bulletins, warnings and flight monitoring for the aviation sector. BMI also provides: i) 10-day forecasts; ii) monthly bulletins on climate information; and iii) monthly rainfall reports. This information can be used by local farmers to determine the effect of climate and weather on crop yield and growth. However, as a result of BMA's limited financial capacity, these bulletins will not be continued in the future. In addition, limited technical capacity has reduced the accuracy of the information provided by these bulletins.

Currently, BMA has six synoptic stations, 20 agro-climatological stations and 70 post-rain gauges. Under the CIRDA project, 10 AWS, 3 synoptic stations and 7 agro-climatological stations have been installed to strengthen weather information in Benin. In addition, 9 AWS have been installed in the north of Benin through the GIIF project. The Department of Water also generates information from their own AWS, but currently this information is not shared with BMA.

Medium- and long-term outlook

To increase the income generated from products and services provided BMA assessments need to be undertaken. Currently, the partnership between BMA and the agri-business sector is being evaluated.

The UNDP-GEF project **Strengthening climate information and early warning systems in Africa for climate resilient development and adaptation to climate change** will increase the capacity of observation networks and hydro-meteorological services to monitor and predict climate variability and extreme weather events – particularly floods, droughts, sea level rise and strong winds. This objective will be supported by: i) increasing the capacity of national hydro-meteorological services and environmental institutions to monitor extreme climate and weather change; and ii) efficiently and effectively using hydro-meteorological and environmental information to issue early warnings and seasonal forecasts, thereby promoting long-term development plans. Through this project's activities, BMA will become financially sustainable as revenue-generating forecasts can be tailored and sold to end users. These tailored forecasts will also be beneficial to local communities who rely on seasonal forecasts to inform agricultural practices. In addition, the provision of early warnings and seasonal forecasts will enhance the preparedness of local communities to extreme weather events.

Budget and expenditures

The Government of Benin finances the recruitment of staff and consultants. BMA also does consulting work for NGOs, other government departments and research institutions. If the information provided is of national interest, then the consulting service is provided freely. If the information is generated for private interest, BMA is permitted to charge for their work.

Public-private partnerships (PPPs)

While there is a legal framework to promote PPPs in Benin, there is limited collaboration between the private sector and BMA. To establish PPPs in the country and support private sector funding initiatives, workshops need to be held with BMA and private sector representatives to determine opportunities for collaboration. Involvement between the private sector and BMA are detailed below:

- The agricultural sector produces data that informs farmers of rainfall patterns. However, the equipment that generates this information is not compliant with WMO standards. As a result, these data is not shared with BMA.
- There are, however, partnerships between BMA, research institutions and universities. For example, the World Bank has facilitated collaboration between BMA and insurance companies to provide WIBI to farmers.
- The Global Index Insurance Facility also assisted BMA in northern Benin to establish AWSs, undertake maintenance and collecting monthly data. The workshop on Atmospheric Modelling (L'AMA) then assisted with transferring these data to CIRAD in France where it is analysed and indices are developed to determine: i) the end of the growing season; and ii) the threshold value for rain and drought that inhibits crop growth.
- In addition, BMA has collaborated with the National Meteorological Services of Spain on the METAGRI project. This project, which was implemented in Sahel countries in 2009, and in Benin since 2012, aims to communicate the impact of climate and weather on farmers. In addition to BMA, stakeholders in Benin include the Ministry of Agriculture, Ministry of Food Security and researchers at local universities. These stakeholders collect information from farmers during field visits, including the type of crops grown and the timing of planting. This information is used to guide training for farmers on sustainable management of natural resources and the importance of meteorology for the agricultural sector. Between 2013 and 2014, 790 farmers were involved.

Obstacles

Obstacles to development of BMA include *inter alia:*

- Limited distribution of observation stations;
- slow transmission of data from manual hydro-meteorological stations;
- poor long-term planning of budgets;
- shortage of skilled technical staff within BMA;
- limited collaboration between different, localized early warning initiatives;
- inconsistent cross-sectoral data sharing and dissemination;
- absence of a standard operating procedure to disseminate warnings; and
- limited tailoring of climate and weather information to end user needs.

### *C5.2.2 Burkina Faso*

Mission and mandate

Since 1972, the Department of Meteorology (DoM) in Burkina Faso has been responsible for providing all meteorological services[167]. The General Directorate of Meteorology (GDM) is mandated with regulating, planning and implementing Burkina Faso's policy on climate and weather activities[168]. The mission of GDM is to: i) develop and direct the management of the country's meteorological observation networks; ii) monitor Burkina Faso's alignment with international meteorological organisations; iii) collaborate in regional and global networks to facilitate the exchange of information; iv) contribute to the prevention and management of natural disasters; v) improve national climate and weather forecasting capabilities; vi) undertake climatological research; vii) monitor climate change; and viii) participate in the World Watch Meteorology[169] organisation.

[167] http://www.un-spider.org/links-and-resources/institutions/burkinabe-department-meteorology-dm. Accessed 11 September 2015.
[168] http://www.meteoburkina.bf/. Accessed 11 September 2015.
[169] http://www.meteoburkina.bf/. Accessed 14 September 2015.

Burkina Faso has a network of ~160 meteorological observation stations. Since 1980, data generated from these stations have been digitized[170]. These data are used to produce 10-day agro-meteorological bulletins which include information on humidity, evapotranspiration and solar radiation. These data, along with parameters on rainfall, temperature and wind, are made accessible in graph and table formats[171]. In addition, the Department of Meteorology provides forecasts on precipitation and temperature at the beginning and end of the rainy season.

Data collected by weather stations are used to generate forecasts and warnings, which are regularly transmitted through radio and television. However, the limited distribution of weather stations compromises the accuracy and quality of weather forecasts[172].

[170] http://www.idare-portal.org/sites/default/files/Data_Rescue_Expert_Mission_Burkina_Faso.pdf
[171] http://www.wamis.org/countries/burkina.php. Accessed 14 September 2015.
[172] Available at: https://www.gfdrr.org/sites/gfdrr.org/files/documents/Country_Program_Burkina_Faso.pdf Accessed 11 September 2015.

Medium- and long-term outlook

The objective of the UNDP-GEF project **Strengthening climate information and early warning systems in Africa for climate resilient development and adaptation to climate change** is to build capacity within Burkina Faso to plan for weather extremes and climate hazards by strengthening existing infrastructure, EWSs and improving climate data collection and dissemination. To achieve this objective, the project will: i) enhance the capacity of national hydro-meteorological services and environmental institutions to monitor climate and extreme weather events; and ii) use hydro-meteorological and environmental information effectively to issue early warnings and seasonal forecasts. The project activities will also allow forecasts in Burkina Faso to be tailored for specific needs, for example to deliver warnings of droughts and floods to local communities.

Budget and expenditures

The main source of income for the DoM in Burkina Faso is the aviation sector. This income is used to maintain the network of observation stations and pay DoM salaries. The products and services that generate profit for the DoM are climate databases and maps that contain data on average rainfall. The demand for these products and services can be increased by improving their quality, as well as increasing awareness within the DoM of potential opportunities to generate revenue.

Public-private partnerships (PPPs)

There is no dedicated PPP unit in Burkina Faso. However, the private sector can approach the Chamber of Commerce to indicate they are interested in a forming partnership. Alternatively, private sector companies can directly approach the DoM and reach an agreement, including the development of a MoU, the Chamber of Commerce does not need to be consulted.

Obstacles

Development of the DoM is prevented by the following obstacles:

- Outdated and poorly maintained hydro-meteorological monitoring infrastructure;
- limited distribution of observation stations;
- limited number of automated weather stations; and
- limited budget to maintain equipment.

### *C5.2.3 The Gambia*

Mission and mandate

There is currently no information available on the Gambia National Meteorological Service's (GNMS) mission and mandate.

Medium- and long-term outlook

Although GNMS is funded by the government, legislation is being drafted to allow GNMS to develop into a semi-autonomous organisation. This development would allow GNMS to engage with the private sector, including agriculture, fisheries, construction and aviation. Increased engagement with the private sector will increase GNMS revenues. Currently services provided to the private sector are overseen by the central government, with GNMS receiving only a small portion of the revenue.

The objective of the UNDP-GEF project **Strengthening climate information and early warning systems in Africa for climate resilient development and adaptation to climate change** is to strengthen early warning systems and the climate monitoring and

adaptation capabilities within the Gambia. To achieve this objective, the project will: i) support the transition of GNMS toward financial sustainability; ii) install, upgrade and maintain the hydro-meteorological infrastructure of the Gambia to meet international standards for EWSs; and iii) train staff to operate EWSs and plan for medium- and long-term climate adaptation. In addition to increasing the capacity of the Gambia to monitor and forecast extreme weather and long-term climatic changes, this project will increase the technical capacity of GNMS staff.

Budget and expenditures

GNMS currently receives all of its funding from the government.

Public-private partnerships (PPPs)

There is an Act currently under review that, if passed, would enable GNMS to form partnerships with mobile operators as well as companies in the fishery and marine sectors. These partnerships would enable GNMS to generate additional revenue, which can be reinvested to improve meteorological infrastructure and technical expertise.

Presently, a PPP exists between GNMS and sponsors that pay for advertising space before and after the weather forecast. These advertising revenues are used to cover broadcasting costs.

As an indication of the potential market with which GNMS could engage, sectors in the Gambia that would benefit from reliable and detailed forecasts include *inter alia*:

- Civil Engineering Companies contracted to construct roads and bridges that require information on rainfall distribution, temperature and wind patterns.
- The Tourism Management Board that requires information on temperature fluctuations, rainfall and incoming storms.
- The Civil Aviation Authority (GCAA) for Aeronautical Services that requires information for principal users of climate and weather data to assist with navigation.
- The Gambia Ports Authority (GPA) for marine navigation that requires information on incoming storms, high and low tides, sea waves (rough) and wind speed.
- The Building Construction Companies that requires information on rainfall distribution, wind direction and speed and the temperature regime.
- The Gambia Football Federation (GFF) that requires information on incoming storms.
- The Gambia National Water and Electricity Company (NAWEC) that requires information on the quantity of rainfall distribution for each region for borehole drillings and assessing water table resources.
- The Fisher Folk Associations that require information on wind storms to avoid or limit loss of life and property damage.
- The Farmers' Associations and Livestock Associations that require information on the timing of rainfall onset, rainfall quantity and timing of rainfall cessations.
- Poultry Farmers that require information on temperature variation which is linked to the production and rainfall quantity for drinking water.
- Insurance Companies that require information on weather variables to determine pay-outs.
- Commercial Banks that require information on seasonal forecasts to determine loan agreements with farmers.

Obstacles

The obstacles to the GNMS' development include *inter alia:*

- Limited capacity to develop sector-specific services and products;
- limited capacity of GNMS to communicate products to end users, especially rural communities;

- obsolete or inadequate climate-monitoring infrastructure, which limits data collection and the provisioning of meteorological services;
- shortage of skilled technical staff, thereby reducing the reliability and accuracy of forecasts;
- a mismatch between generated climate information and the information required by end users; and
- limited use of climate information and warnings at the community level.

*C5.2.4 Liberia*

Mission and mandate

The Liberia National Meteorological Service (LNMS) was established in 1952 under the Ministry of Public Works, but was later transferred to the Ministry of Transport[173]. The extended civil war (1989–1997; 1999–2003) has resulted in limited institutional and technical capacity to conduct research on climate and weather. A limited availability of weather observation equipment has hampered the collection of climate data. In addition, a centralized national climate database has not been developed and consequently, there is only limited climatological research being undertaken in Liberia. As a result of these challenges, Liberia has not developed any reliable EWSs and has only limited public weather services[174].

While the Ministry of Transport is the directorate of LNMS, meteorological services are distributed among other governmental ministries and agencies (see Table C6.6).

**Table C6.6.** Ministry and agencies responsible for NHMS[175].

| Ministry/Agency | Staff | Equipment |
|---|---|---|
| Ministry of Transport | • 3 meteorologists<br>• 1 meteorological technician | • No observational stations |
| Ministry of Lands, Mines and Energy | • 1 meteorologist<br>• 2 meteorological technicians | • 5 hydrometric stations<br>• 6 rainfall stations<br>• 1 meteorological training station<br>• 1 hydrometric training station |
| Roberts International Airport (RIA) | • 1 meteorologist<br>• 5 meteorological technicians-in-training<br>• 3 additional meteorological technician trainees.<br>• No ICAO/WMO-certified or -trained weather forecaster | • 1 Automatic Weather Observing Station<br>• 1 outdated Aeronautical Message Processor System (AMPS)<br>• 1 MSG-PUMA station has been upgraded to PUMA Synergie<br>• 1 obsolete Stevenson Screen containing dry and wet bulb thermometers as well as maximum and minimum thermometers<br>• 1 manual rain gauge |
| Liberia Domestic Airports Agency (LDAA) | • 1 meteorologist<br>• 3 meteorological technicians being trained on-the-job | • 1 wind vane for measuring wind direction and speed<br>• 1 manual rain gauge |

Medium- and long-term outlook

[173] https://www.wmo.int/cpdb/dashboard/liberia. Accessed 23 September 2015.
[174] http://unfccc.int/resource/docs/natc/lbrnc1.pdf. Accessed 23 September 2015.
[175] http://unfccc.int/resource/docs/natc/lbrnc1.pdf. Accessed 23 September 2015.

The LDCF-GEF funded project **Strengthening Climate Information and Services to Enhance Climate-Resilient Development and Adaptation** seeks to promote effective climate monitoring and EWSs. The objectives of the project are to: i) develop a streamlined, customised and consolidated EWS informed by accurate climate information; ii) increase the distribution of meteorological monitoring stations; and iii) establish communication channels to disseminate climate information and early warnings. These objectives will be supported by the following outcomes:

1. An increase in the capacity of hydro-meteorological services and associated networks to monitor and predict extreme weather, climate-related hazards and climate trends.
2. The promotion of efficient and effective use of tailored climate, environmental and socio-economic data to supply information to inform decision-making.
3. An improvement in the awareness of the private sector, government institutions and local communities on risks associated with climate change. This improved awareness will also inform development policies and strategies.

Through the EWSs developed by this project, smallholder farmers, business owners and vulnerable communities will be able to reliably anticipate climate hazards and develop plans to minimise risks and losses.

The **Draft legislation for the establishment of a National Meteorological Agency** (NMA) has been validated by stakeholders and is under review before it can be enacted into law. Through this law, NMA will be mandated with monitoring and observing the atmosphere as well as providing climate and weather information and services.

With assistance from the WMO, a **National Development Plan** (NDP) and project proposal were prepared in 2010. The main objectives outlined in the NDP include: i) human resource development; ii) the establishment of climate and weather-observing stations; iii) acquisition of facilities to process, manage and communicate weather forecasts; iv) upgrading of the MSG-PUMA station with funding provided by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT); v) installation of the AMESD Station, funded through EUMETSAT; vi) establishment of a Central Forecasting Office (CFO); vii) establishment of an effective EWS; and viii) participation in the WMO GCOS Program.

The **Spain-WMO Voluntary Cooperation Programme (VCP)** was established in Liberia to promote the country's agricultural production and food security through the provision of meteorological services. The Spanish State Meteorological Agency (AEMET) will provide Liberia with technical assistance to train 200 farmers and establish 10 rainfall stations throughout the country. In addition, the Government of Liberia will be provided with 200 rain gauges and 200 stickers.

Budget and expenditures

Most of LNMS' funding is provided by government[176]. However, LNMS does derive additional income through projects funded by international organisations. For example, the Government of Norway is providing support to LNMS through the provision of equipment – including flow gauges and AWSs – and technical training[177]. LNMS provides services and products to both the aviation sector and the Public Weather Service (PWS). However, commercial activities are not allowed[178].

Public-private partnerships (PPPs)

There is currently no information available on PPPs in Liberia.

Obstacles

[176] https://www.wmo.int/cpdb/dashboard/liberia. Accessed 16 August 2015.
[177] http://ews-undp.blogspot.co.za/2013/03/summary-of-liberia-second-mission.html. Accessed 22 July 2015.
[178] https://www.wmo.int/cpdb/dashboard/liberia. Accessed 28 July 2015.

As a result of historical political conflict, several obstacles need to be addressed to increase the institutional, financial and technical capacity of the NHMS in Liberia. These obstacles include *inter alia*:

- Limited climate and weather monitoring equipment to inform data collection, analysis and the provision of timely meteorological services;
- limited access to climate models and technology, thereby decreasing technical expertise and the capacity to provide climate forecasts;
- weak institutional coordination, resulting in limited packaging, translation and dissemination of climate and weather information and early warnings;
- inadequate environmental databases to assess the risks posed by weather variability and climate change[179];
- absence of a national institution/entity mandated to collect systematic atmospheric data for the provision of climate and weather information and services;
- absence of a national developmental/strategic plan – prior to May 2010 – to develop the meteorological sector;
- considerable shortage of meteorological stations – only two can be considered functional and even these do not monitor a wide range of climatic parameters;
- absence of data-processing and forecasting facilities;
- inadequate public weather services;
- limited public education on, and awareness of climatology;
- inadequate Information and Communication Technology (ICT) facilities for data processing; and
- limited support for atmospheric research[180].

### *C5.2.5 Sao Tome and Principe*

Mission and mandate

Sao Tome and Principe's National Meteorological Institute (NMI) is the sole provider of meteorological information in the country. The technical capacity of NMI has been enhanced by selective training provided through the African Adaptation Programme (AAP). NMI shares climate information via radio, television, SMS Frontline System and newspaper.

Medium- and long-term outlook

There is currently no information available on the medium- and long-term outlook in Sao Tome and Principe.

[179] RoL. 2013. Project brief: strengthening climate information and services to enhance climate-resilient development and adaptation.
[180] http://unfccc.int/resource/docs/natc/lbrnc1.pdf. Accessed 21 September 2015.

Budget and expenditures

Income for NMI is not provided by the government. Revenue is generated through services provided to the aviation sector, but there is scope to increase this revenue by engaging with the fisheries sector, as well as the banking and insurance sectors. Currently, the revenue generated from the sale of services to the aviation sector is ~US$75,000.

Public-private partnerships (PPPs)

Since 2014, there has government support for the development of PPPs. Indeed, PPPs have great potential to improve food security in the country by providing early warnings of hazardous weather events to farmers. However, the legal framework for PPPs in Sao Tome and Principe is poorly developed as a result of political instability. In addition, challenges relating to land tenure have prohibited partnerships between agri-businesses and the public sector.

Obstacles

The primary obstacle identified to the development of NMI is limited technical capacity to use EWS equipment and manage EWS-generated data.

*C5.2.6 Sierra Leone*

Mission and mandate

The Sierra Leone Meteorological Agency (SLMA) was established to: i) secure the safety and welfare of citizens by providing timely weather warnings; ii) contribute to the socio-economic development of the country; iii) collect and retain custodianship of historical meteorological and climatological data and records; and iv) fulfil international obligations under several conventions, including *inter alia* the WMO, UNFCCC and UNCCD. The mission of SLMA is to provide cost-effective climate services by collecting, processing, archiving and disseminating meteorological and climate information and services. This information will be used to contribute to the management of Sierra Leone's economy, particularly for enhancing the safety of citizens, limiting damage to property and protecting ecosystems[181].

Sierra Leone has undertaken a programme to repair its observation stations that were damaged during the country's long civil war (1991–2002). This has included the development of a computerized database, as well as the acquisition of modern equipment for communication and weather observations. Consequently, there have been considerable improvements to the accuracy of data generated by SLMA, as well as the dissemination of weather and climatological services. However, sparsely distributed synoptic stations and a shortage of staff continues to be a limiting factor in the development of SLMA.

Medium- and long-term outlook

Through the **Sierra Leone Meteorological Services Strategic Plan** (2011–2015), the following strategic goals will support the mission and vision of SLMA:

1. Effective governance systems;
2. strong partnerships that promote the quality of climate and weather monitoring and services throughout Sierra Leone;
3. the development of climate and weather change policies;
4. increased financial and technical capacity to promote the sustainability of SLMA services;
5. improved management of staff and volunteers through training; and

[181] Sierra Leone Meteorological Services Strategic Plan, 2011–2015.

6. improved channels of communication within SLMA, and between stakeholders, partners and end users.

The **Five-year Capacity Development and Service Delivery Programme** seeks to build on the support provided to strengthen the institutional capacity of SLMA following Sierra Leone's civil war. This support includes: i) upgrading the Sierra Leone Weather Observing Network through the installation of six AWSs; ii) training of SLMA technical staff in the installation and maintenance of the AWS system by the UK NHMS, supported by UNDP; iii) training of 30 SLMA staff as technical, observers, meteorologist and forecasters; and iv) recruiting and training of eight weather observers, three technicians and three student meteorologist. To promote the long-term capacity development of SLMA, this programme aims to *inter alia*:

- Complete AWS installations and related training activities;
- initiate weekly radio broadcasts;
- conduct stakeholder meetings;
- increase the capacity of meteorological staff;
- promote exchange programmes between SLMA and international meteorological offices;
- initiate forecaster and Agromet training;
- complete digitisation of national meteorological data;
- complete forecaster training;
- initiate TV broadcasts;
- provide basic services relating to weather hazards to the national government; and
- provide basic services to the agricultural sector.

Public-private partnership (PPPs)

There is currently no information available on PPPs in Sao Tome and Principe.

Budget and expenditures

There is currently no information available on the budget and expenditures in Sao Tome and Principe.

Obstacles

There is currently no information available on the obstacles that Sao Tome and Principe's NHMS experiences.

# Annexure C6. Case studies of private weather companies operating in Africa

## C6.1. Earth Networks

Earth Networks is a private company that provides weather information, in particular information on lightning accessed through a worldwide lightning sensor network. In addition, Earth Networks uses a broad network of sensors to measure carbon dioxide and methane to improve the modelling of greenhouse gases in the atmosphere.

*Earth Networks and their presence in Africa*

Earth Networks has approached several NHMSs in Africa to assist them with improving their business models. Several examples of these partnerships are described below.

Guinea

In 2013, Earth Networks formed a PPP with the NHMS in Guinea, which resulted in the first technologically advanced EWS for severe weather in a Least Developed Country (LDC). The objective of the partnership was to build the capacity of Guinea's NHMS to monitor and predict thunderstorms and produce timely and relevant climate warnings. Earth Networks also partnered with Cellcom Guinea to generate weather information by installing a number of lightning sensors and weather stations on cell-phone towers that transmit data to Earth Networks' data centres for processing and analysis. As a result, the volume of collected data increased. In addition, NHMS staff were trained on how to collect and analyse the data generated from the telecom towers.

Uganda

In Uganda, Earth Networks is part of the Global Climate Resilient Partnership. This partnership provides a platform through which a broad-based SMS service is linked to disaster risk reduction efforts. In addition, to determine the effectiveness of UMA's interventions[182], Earth Networks conducted a study in 2011 on severe weather warnings and the willingness and ability of local people to pay for these services. The study concluded that once a national framework for PPPs is established and equipment to produce the data is provided, weather information can be improved and disseminated across different sectors.

*Earth Networks' business model*

To improve the process of collecting information from observation networks and disseminating this information to the private sector, Earth Networks has introduced a model of joint data processing and information sharing through partnerships, while leveraging technology that is context specific. Earth Networks facilitates the establishment of PPPs – for example between the NHMS and mobile phone companies – to assist the NHMS with developing and selling weather products that can generate revenue. The profits of these sales are shared with the NHMS, thereby creating an additional revenue stream for the NHMS. The WMO supports this joint data collection process.

[182] UMA's interventions include deploying more weather stations and lightning sensors. These will collect weather information and produce forecasts and warnings in collaboration with partners, including HNI. The Clinton Health Access Initiative (CHAI) then disseminates this information to local communities, particularly cattle owners and fishermen.

In Guinea, Earth Networks cooperates with mobile phone companies and representatives of the aviation, agriculture, energy and transport sectors. In Benin and Guinea, Earth Networks and the NHMS cooperate with ASECNA[183] – an air traffic control agency for Madagascar and Francophone Africa. In these countries, Earth Networks uses ASECNA's facilities as there is limited technical capacity within the national aviation industry to generate weather information. ASECNA also contributes financially to the NHMS by covering the costs of operation and maintenance. In Uganda, the NHMS cannot provide the required information for the aviation industry and subsequently do not get the full payment from the aviation industry for cost recovery to support their services.

Earth Networks uses cloud computing to process data, which assists NHMS staff in each country to analyse weather information. This cloud computing enables: i) sharing of data; and ii) resale of data.

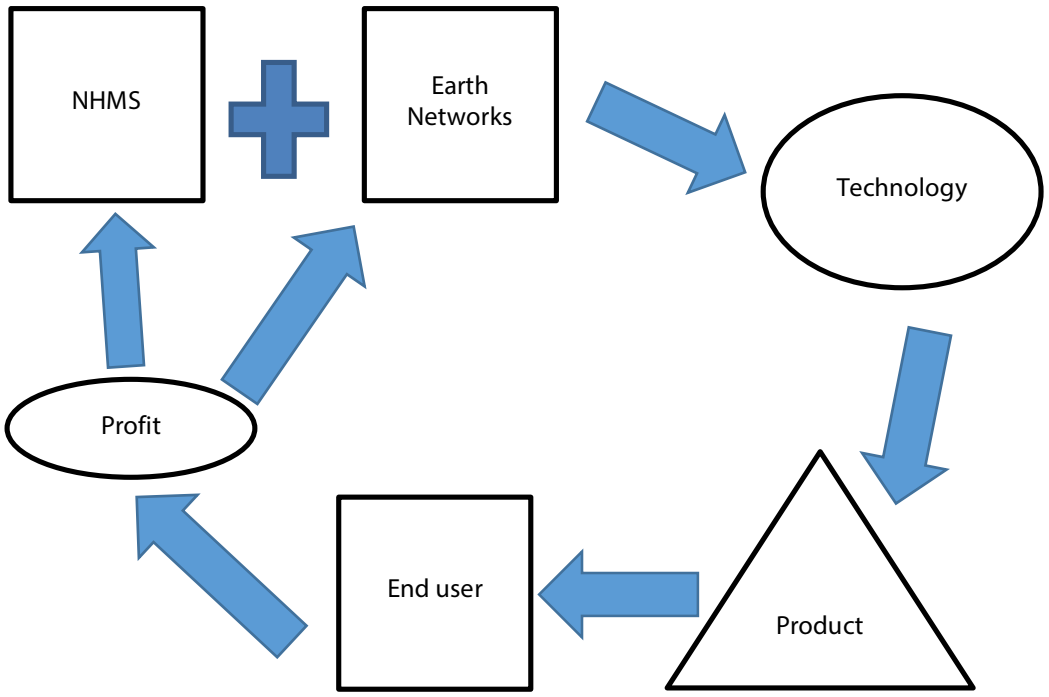


**Figure C6.1.** Conceptual diagram illustrating the interaction of Earth Networks and NHMS partners.

*What products and services does Earth Networks deliver?*

Earth Networks' products and services include:

- **PulseRad**, which is a proxy radar visualization tool that provides radar-like visibility to identify areas that are threatened by heavy rain, strong winds, flash floods, as well as extended droughts and rains.
- **Dangerous Thunderstorm Alerts** provides early warnings of extreme weather such as lightning, tornadoes and hail. With the knowledge that in-cloud lightning partly determines the formation and intensity of different types of extreme weather, Earth Networks established a large and advanced lightning sensor network. The sensors in this network continuously monitor, calculate and report where and when lightning strikes occur either in the clouds or on-the-ground, collectively referred to as "total lightning" by meteorologists.
- **ENcast** is a cloud-based forecasting tool that uses current weather and lightning data to improve localized hourly forecasts.

[183] ASECNA: The Agency for Aerial Navigation Safety in Africa.

*Relationship with the NHMS and benefit sharing*

The benefit of piloting initiatives in developing countries is that a company – such as Earth Networks – can rapidly introduce the newly developed technology for EWS and cloud-based computing. That is, Earth Networks can act as a broker between the NHMS and the private sector weather users by combining information provided by the NHMS with data generated from its own technologies. This information is then disseminated to the end user. However, providing this information to the end user – i.e. reaching the Last Mile through EWS – can be complex and costly. Consequently, new technology has been developed – such as the mobile app, Weatherbug – which links the NHMS to the end user through mobile phone technology, thereby enabling EWS to cross the Last Mile.

*Potential for up-scaling Earth Networks initiatives in developing countries*

Governments in developing countries often engage with various short-term projects that provide new and costly equipment, instead of focussing on capacity building. To address this gap, Earth Networks: i) encourages NHMSs to adopt cost-effective and innovative approaches to purchasing technology; and ii) facilitates capacity building in NHMS staff working within newly established PPPs. In addition, through PPPs, Earth Networks assists in the development and sale of weather information products and a portion of the revenue generated from these products accrues to NHMSs.

## C6.2 Meteogroup

*Meteogroup's background and its presence in Africa*

Meteogroup aims to be a private weather information company operating globally. While the company has established offices in developing countries such as the Philippines, opportunities in Africa have not yet been explored. Meteogroup's entry into Africa will be determined by each country's interest in the products and services provided by Meteogroup or the interest of the clients that are operating in these countries[184].

*What is Meteogroup's business model?*

Meteogroup purchases weather data primarily from NHMSs and international organisations, such as NOAA and EUMETSAT. In addition, Meteogroup obtains data from: i) AWSs; ii) radars; iii) climate models; iv) Interactive Computer Worded Forecasts (ICWF); and v) information from the UK and German NHMSs. Meteogroup then combines all of these data and provides a high-quality weather forecast that can be sold. The company has ~140 forecasters that provide products and services to clients in their local language. These products and services are specific to end user requirements.

The products and services provided by Meteogroup are available to end users through subscriptions. For example, media and consumer groups pay a fixed fee for Meteogroup to deliver scripts to broadcast companies. Meteogroup also often provides their own weather presenters for television and have their own apps and website to provide weather information. Meteogroup's business model is depicted in Figure C6.2 below.

[184] Personal conversation with Mr D. Schulze of Meteogroup Germany on 19 October 2015.

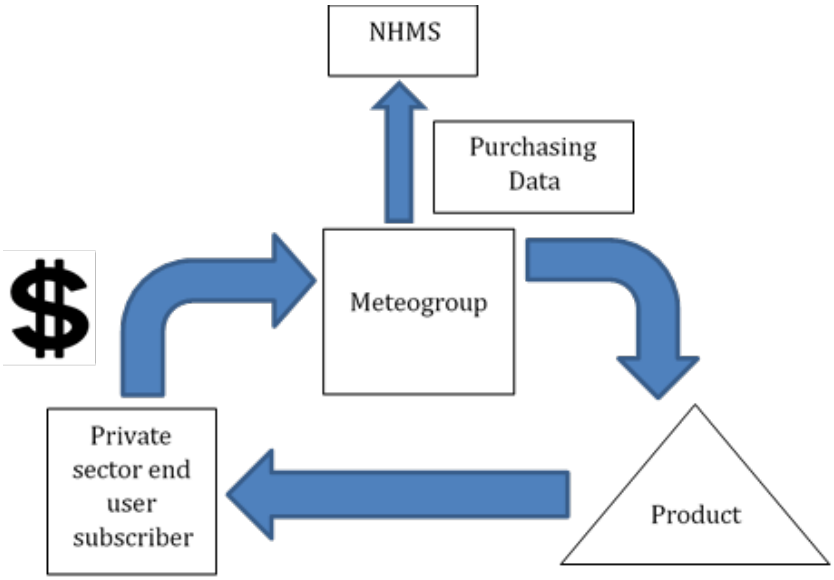


**Figure C6.2.** Conceptual diagram illustrating Meteogroup's business model.

*What products and services does Meteogroup deliver?*

Meteogroup's research and development group has developed several in-house techniques to improve short-term forecasting using radar and satellite images. The products and services most used by the company are outlined below:

- **Model Output Statistics (MOS)** is a statistical weather forecasting technique developed by MeteoGroup that combines several models into one forecast. This approach improves the quality, accuracy and resolution of forecasts. For example, Meteogroup provides forecasts every hour over a 15-day period for ~65 variables in over 20,000 locations around the world. All forecast information is updated every hour and in some cases, every 15 minutes.
- The **Weather Research and Forecasting (WRF) Model** is an open-source model that Meteogroup uses to enhance their own model and adapt it to any location on the globe. Compared with global models – which typically have low resolution – WRF is more accurate in topographically complex areas and when extreme weather occurs, such as strong winds or extreme convection. WRF also includes the effects of varying land use on the weather. The model is flexible and has multiple uses, for example forecasting, hindcast studies, air quality studies, regional climate modelling and short-term nowcasting.
- **Satellite MOS** uses real-time, high-resolution satellite images. The satellite images are decoded automatically and adapted according to prevailing wind direction and speed, thereby providing cloud and radiation forecasts.
- **A precipitation radar** shows the intensity and spatial distribution of precipitation but not the type of precipitation (e.g. rain or snow). MeteoGroup has developed a technique to combine radar data with other information to provide images that illustrate the type and intensity of the precipitation event. In addition, the radar can be used for severe weather warning services.
- **Radar MOS** extrapolates radar images over time and combines these images with more general forecasting tools to improve forecasts of precipitation rate and probability. Meteogroup has developed this precipitation forecast particularly for short-term forecasting.
- **The Nautical MeteoBase (NMB)** is an innovative weather forecasting system for the maritime market that combines high-quality information from the world's leading weather models into a single forecast. The NMB integrates the best characteristics from each of the forecasting models.
- **Lightning Tracker** provides accurate, real-time lightning data and is designed as both a standalone product and as an integrated add-on to MeteoGroup's products. When lightning is detected in any a particular location, the colour of that location changes on a display screen and an optional sound alert is produced for immediate warning. A pop-up window will also appear to indicate the location of the lightning strike, along with strike statistics – such as strength, type (cloud-to-cloud or cloud-to-ground) and polarity. In addition to a Lightning Tracker app, there is also the option of receiving alerts by email or SMS.

- **The Severe Weather Centre** in Europe uses an approach based on Meteogroup's innovative warning system, whereby a four-step warning provides information about the intensity of the forecasted severe weather. The warning system uses the flexible polygon principle, which allows warnings to be defined individually and according to requirements of a defined area (e.g. postcode, district), line (e.g. rail network, power lines) or geo-coordinates (e.g. buildings). Warning thresholds can be adjusted for individual warning levels according to customer preferences.

In addition to using radar and satellite data to provide climate services, a Historical Weather Database was established. These database contains information from the mid-twentieth century to the present day and contains a range of weather parameters. These include *inter alia*: i) wind speed and direction; ii) temperature; iii) dewpoint: iv) cloud cover; v) radiation; and vi) precipitation. Data on these parameters is collected by Meteogroup from several international sources, checked, categorised and added to the database. To fill in any missing observations, several techniques – such as the model output statistics (MOS) – are used to adapt these data to the local climatology of each location.

*Relationship with the NHMS and benefit sharing*

In most countries, the relationship between Meteogroup and the NHMS is a combination of customer-supply and competition. However, over the last 20 years ago, NHMS has made their data more freely available and have begun to diversify their activities. As a result of this improved data accessibility and clear separation of roles and responsibilities, Meteogroup generally has a good working relationship with the NHMS in most countries.

In Germany, Switzerland and the Philippines, Meteogroup has developed an extensive network of AWS through strategic partnerships with NHMSs. However, in most other countries, Meteogroup requires the basic infrastructure provided and maintained by the NHMS. Because of this requirement, the company cooperates rather than competes with the NHMSs of the countries in which they operate.

Meteogroup does not share revenues with NHMSs. In Europe, this would require an exclusive relationship. Instead, Meteogroup pays a fixed price to the NHMSs for their data, which is often standardised at ~11% of the revenue generated from Meteogroup's sales. Prices for data access may vary according to data licence agreements and factors within the weather market.

*Potential for upscaling*

There is potential for Meteogroup to upscale into other countries, including those in Africa, but the following factors would promote upscaling:

- political stability;
- clear and enforced legislative and regulatory frameworks;
- the presence of an NHMS with a reliable observation network;
- sectors with a strong dependence on weather information;
- established communication channels with farmers; and
- a basic level of education within end users to understand weather information

## C6.3 Speedwell Weather

*Background on Speedwell Weather*

Founded in 1999, Speedwell Weather (SW) supplies historical and real-time weather data for tens of thousands of weather reference sites around the world. SW has direct data supply agreements with a number of national meteorological services and provides a single point-of-contact for the provision of high-quality weather data to the energy, agriculture, banking, insurance and weather risk management sectors.

SW has worked in Africa, but because data limitations, the company does not work directly with national government agencies or NHMSs. Instead, SW obtains climate data from WMO and other service providers. Before joining SW, a representative of the company – Mr David Whitehead – worked in Malawi and encountered the following challenges: i) NHMS staff are not trained on the value of climate data and either under or over-price the data; ii) data collected by the NHMS are maintained in Excel sheets or on hard copies, which impedes efficient data distribution; and iii) the quality of climate data are limited.

*What is SW's business model?*

SW has direct supply agreements with many National Meteorological Services worldwide. SW approaches a country, makes an agreement and purchases weather stations from which SW has unrestricted use of the data. Then SW adds value to the data, packages it and sells to end users. In addition, SW sells software – which individuals and businesses can subscribe to, to get access to several data packages. The business model of Speedwell Weather is depicted in Figure C6.3 below.

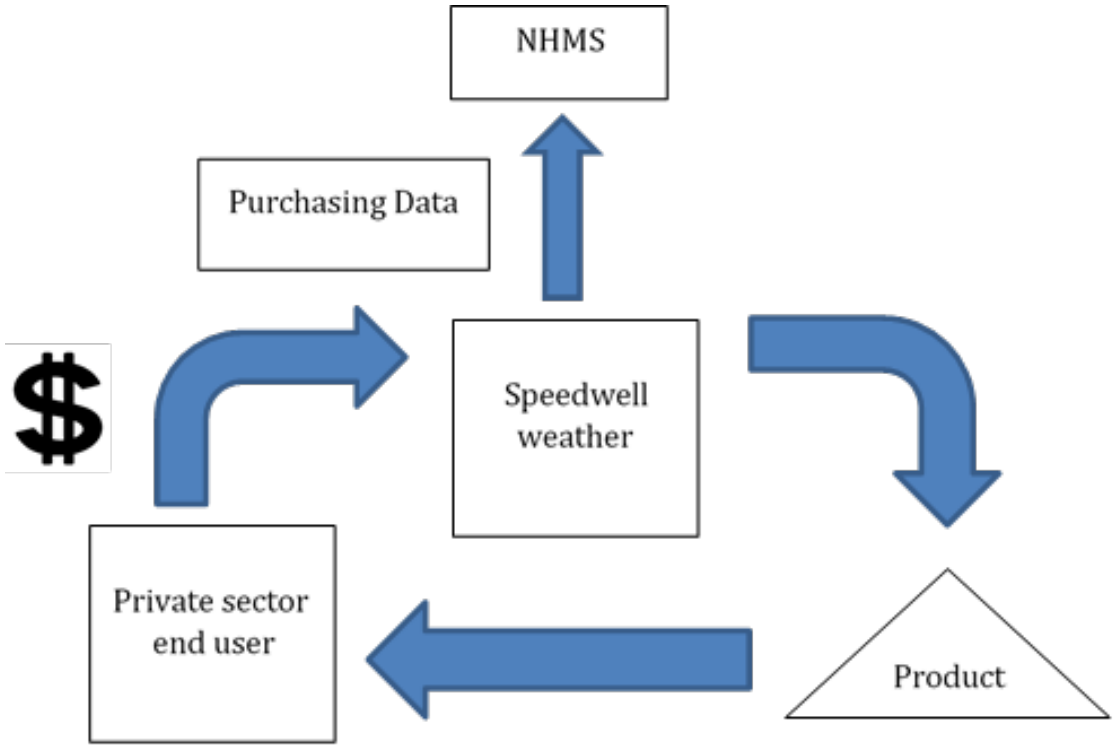


**Figure C6.3.** Conceptual diagram of SW's business model.

*What products and services does SW deliver?*

SW's range of products and services includes *inter alia:*

- **The Speedwell Weather System (SWS)** is a pre-eminent weather derivative pricing and risk management software. SWS is an internally operated client-server software application for the weather market. SWS covers weather derivative pricing, portfolio risk management and weather data and forecast warehousing. Both the capital markets and portfolio/actuarial methodologies used in the weather market are supported. SWS integrates with historical weather data and forecasts supplied by multiple providers. SWS offers full support for front, middle and back office functions, including the process management of the entire life cycle of a weather derivative trade. SWS is used by banks, insurance companies, investment funds and energy companies worldwide.
- **Forecast Superpack** is designed for companies with extensive forecast needs. Subscribers can choose from over 2,500 Speedwell downscaled forecasts – plus raw model forecasts – for a single annual fee.
- **Agricultural Data Packs** focuses on agricultural commodities – for example coffee, cotton and wheat. For each commodity, a polygon for important areas (i.e. growing areas) is created and all the available weather stations within that polygon are mapped. If weather station coverage of the agriculturally important areas is inadequate, SW recommends the building of additional weather stations. For each weather station SW can offer: i) daily temperature and precipitation; ii) cleaned, i.e. user-friendly weather data; and iii) historical weather data – as much as three decades' worth – depending on the station.
- **Settlement Data** is used to produce accurate and reliable settlement feeds. All techniques are transparent to the user and can be pre-agreed in contracts. Approaches to ensuring data integrity include "surrounding station analysis", supplementing observations with forecast data, radar and satellite data and for larger transactions installing back-up weather stations.
- **Recalibrated Datasets** are used to re-base historical temperature data for important reference sites by adjusting for known or observed discontinuities that have accumulated over the lifetime of the observations.
- **Quantifying weather risk for private sector** is a service SW provide which assesses revenues of a business to analyse risks.

*Relationship with the NHMS and benefit sharing*

SW encountered some corruption within NHMSs in Africa, resulting in hesitancy on the company's part to start operations in Africa. However, SW may be an important mediator between the NHMS and the private sector to facilitate data sharing. This is because SW obtains data from NHMS and other sources, packages these data according to the needs of their clients, and sells these packages. Consequently, if SW can offer data from the country's NHMS to the private sector, then SW can expand their client base and increase their revenues. NHMSs in developing countries also need compensation and support for their services, particularly because they often do not get this from the government. It is therefore in the public interest that the private sector assists NHMSs to improve the quality of weather information and dissemination thereof.

From SW's perspective, the main problem experienced by NHMSs in African countries is not receiving frequent updates on data. While the NHMSs can prepare historic data, they often do not receive updates from weather stations for logistical reasons – for example, if the stations can only upload data manually. SW can only operate in a country if the incoming data is somewhat reliable and regular, and use *inter alia* technologies, surrounding stations in neighbouring countries and algorithms to fill the data gaps. This approach is also applicable for newly installed weather stations that have little to no historical observations for pricing.

SW is open to partner with NHMSs in Africa as there is a possibility for SW to assist NHMSs with adding value to their data. This is because of SW's extensive experience with managing databases and processing data. For example, SW can offer to maintain the data, ensure data quality and share revenues from data sales with NHMSs in African countries.

*Potential for upscaling of SW initiatives*

Speedwell Weather could for example form a PPP with an NHMS. However, before entering into a PPP, Speedwell Weather needs to: i) understand the data protocol in the country, i.e. how it is stored and collected; ii) review the data quality; and iii) work with the NHMS to build capacity data maintenance and processing and client engagement. The best way to develop solutions to many of Africa's climate and weather-related challenges is to make information widely available.

## C6.4 Infoplaza

*Background Infoplaza and their presence in Africa*

In the mid-1990s, Infoplaza became independent from the commercial branch of the Dutch NHMS (KNMI). Through coverage of weather, traffic and public transport, Infoplaza offers a diversity of consumer services with accurate information to enable smooth and easy decision-making. In addition to addressing consumer needs, Infoplaza offers services to businesses. For businesses and state-owned enterprises, Infoplaza has developed a diverse number of off-the-shelf solutions for general needs, but also tailors products for specific requirements.

Currently, Infoplaza is not directly involved in Africa, but is cooperating with a consultancy on a UNDP project for developing a disaster risk reduction and an EWS in Ghana. Infoplaza was hired specifically to develop a localised weather model and derive precipitation information from satellites.

*What is Infoplaza's business model?*

In addition to providing solutions weather information to customers, Infoplaza offers information on anticipated damage to infrastructure. For example, Infoplaza assesses the extent to which infrastructure of the national railway company will be damaged by wind and rain. Infoplaza can therefore be considered to be a value adder in the private weather company sector.

*What products and services do Infoplaza deliver?*

Infoplaza has three business lines:

1. TV, online and offline. These lines do not generate large revenues, but do increase the company's exposure.
2. Consumer activities (website and apps) using the advertising model, i.e. free to consumers with advertisers paying for including advertisements.
3. Business-to-business in four areas: railways, construction, agriculture and energy. Recently, offshore (gas and oil) has also been included.

Of these three business lines, the business-to business is the most popular.

Particular weather products and services provided by Infoplaza include:

- **Rain radar**, showing actual location of rain in the country.
- **Customised information** such as rainfall patterns for farmers and crop-spraying companies.

*Relationship with the NHMS and benefit-sharing*

There is some collaboration between Infoplaza and the NHMS. For example, Infoplaza and the NHMS have collaborated on a project to build a climate database from precipitation data sourced from satellite images. The data produced by this project will benefit the NHMS, but the technology that results is in Infoplaza's business interest. The NHMS will not receive revenue from this collaboration, but will have free access to the resulting product.

*Potential for upscaling Infoplaza initiatives*

In Africa, the products and services of NHMSs are not as developed as those of NHMSs in Europe and the USA. To improve their products and services, African NHMSs will need to collaborate with the private sector. To advance NHMSs within African countries, collaboration is necessary. Specifically, to be more effective, NHMSs will need to provide products and services according to end user demands. Collaboration with the private sector presents an excellent opportunity for NHMSs to assess market demand. However, developing a market for weather products is difficult and a company needs to promote their products to its users. The effort required to create innovative products and develop the business should not be underestimated.

## C6.5 EcoNet Wireless: Zimbabwe

*Zimbabwe's socioeconomic context*

Zimbabwe is a land-locked country in Southern Africa, bordered by Mozambique, South Africa, Botswana and Zambia[185] (Figure C6.4, below). The country covers a total land area of ~390,000 km$^2$. In 2013, Zimbabwe's Human Development Index (HDI) was 0.492, placing the country into the 'low' human development category[186], with ~68% of the population living below the poverty line[187]. Agriculture is one of Zimbabwe's largest sectors, contributing ~16–20% to the county's Gross Domestic Product (GDP). Moreover, ~60% of individuals residing in rural areas rely on agriculture to support their livelihoods.

**Figure C6.4.** Geographical location of Zimbabwe[188] .


*Introduction to EcoNet Wireless and the EcoFarmer model*

EcoNet Wireless Zimbabwe – hereafter referred to as EcoNet – is Zimbabwe's largest provider of telecommunication services. EcoNet launched its network on 10 July 1998 and became a listed company on 17 September 1998. It is one of the largest companies on the Zimbabwe Stock Exchange in terms of market capitalisation[189]. Key subsidiaries and associates of EcoNet are Liquid Telecom and Transaction Payment Solutions. To date EcoNet has ~9 million subscribers and is Zimbabwe's dominant mobile operator – representing ~65% of the country's mobile market.

[185] http://www.zw.one.un.org/uninzimbabwe/zimbabwe-country-profile Accessed on 22 July 2015.
[186] http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/ZWE.pdf Accessed on 22 July 2015.
[187] http://www.indexmundi.com/g/r.aspx?v=69 Accessed on 22 July 2015.
[188] http://www-tc.pbs.org/frontlineworld/stories/zimbabwe504/images/africa_map.gif Accessed on 22 July 2015.
[189] https://www.EcoNet.co.zw/about-us Accessed on 22 July 2015.

In October 2013 – with investment from/partnership with Agri-Fin Mobile Programme[190] – EcoNet launched a pilot mobile-based WIBI and trade service, named EcoFarmer. The application was developed with the aim of: i) improving agricultural productivity and yields in Zimbabwe; ii) providing local smallholder famers with insurance coverage during periods of drought; iii) providing local smallholder famers with information on various agricultural market trends; and iv) strengthening food security in the country. Additionally, EcoFarmer serves as a conduit for providing weather information via SMS to registered subscribers[191]. The objective of bundling affordable services on one mobile platform – as per the Agri-Fin Mobile's approach – is to increase access to relevant services and thereby improve livelihoods of smallholder farmers[192].

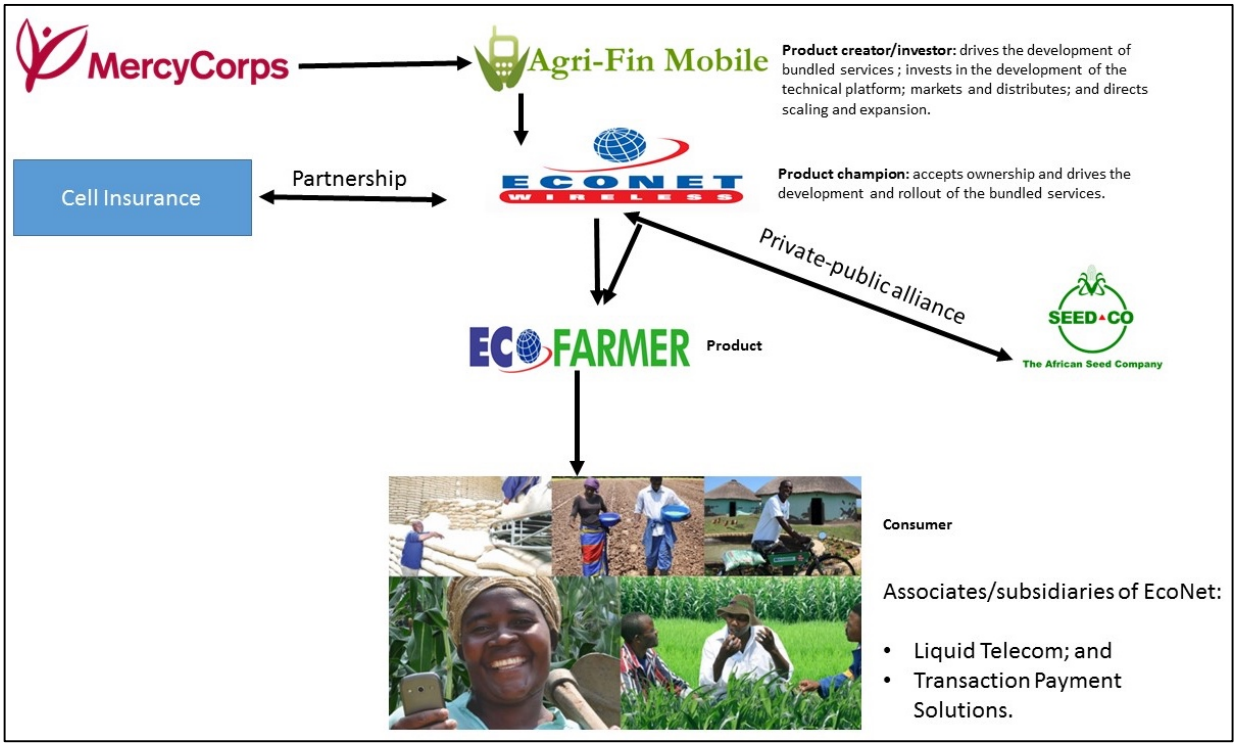


**Figure C6.5:** Conceptual representation of EcoNet's operational partnerships.

[190] http://www.mercycorps.org/research-resources/accelerated-behaviour-change-and-adoption-good-farming-practices-among accessed 28 July 2015.
[191] http://venturesafrica.com/EcoFarmer-boosts-zimbabwes-economic-productivity/ Accessed 22 July 2015.
[192] http://www.agrifinmobile.org/?q=node/93. Accessed 22 July 2015.

EcoFarmer services

A farmer can register to be either a General Farmer; a Registered Farmer; or an Insured Farmer. These categories include various bundled services – see Table C6.6, below.

**Table C6.6.** EcoFarmer user categories[193].

| Category | Associated services | Associated costs |
|---|---|---|
| General Farmer | • Farmer will receive general farming information. | • None. |
| Registered Farmer | • Farmer will receive weekly text messages which include *inter alia*: i) crop data; ii) farming tips; iii) farming information; and iv) market links and updates. | • $1.50 per month to receive messages or $0.05 per day. |
| Insured Farmer | • Farmer will be insurance for the event of crop loss linked to drought or excessive rainfall.<br>• Farmer will receive daily text messages which include *inter alia*: i) weather forecasts; ii) farming tips; iii) information on where and when to sell produce and best price. | • To qualify for a claim of US$100 a farmer will need to pay a premium of US$10 for the whole farming season.<br>• To qualify for a claim of US$25 a farmer will need to pay a premium of US$2.50 for the whole farming season. |

WIBI services for an Insured Farmer

EcoFarmer insures registered smallholder farmers against crop failure during the agricultural season as a result of inadequate or excessive rainfall. Pay-outs from EcoFarmer will occur if less than 2.5 mm of rain falls on a farmers' land for ~25 consecutive days during the rainy and agricultural season (November–April)[194]. The same principle applies if the area receives excessive rainfall. A farmer can pay a premium of US$10 for the entire agriculture season – ~ 8c per day. In the event of a crop failure linked to drought or excessive rainfall this payment will entitle the farmer to claim up to US$100. Alternatively, a farmer can qualify for a claim of up to US$25, if he elects to pay a premium of US$2.50 for the entire agricultural season (Refer to Table C6.6, above). To become insured, a farmer must follow the process detailed in Figure C6.6 (below).

[193] Adapted from: https://www.EcoNet.co.zw/EcoFarmer-faqs. Accessed on 27 July 2015.
[194] http://www.newzimbabwe.com/business-16172-Farmers+benefit+from+EcoNets+crop+cover/business.aspx. Accessed 27 July 2015.

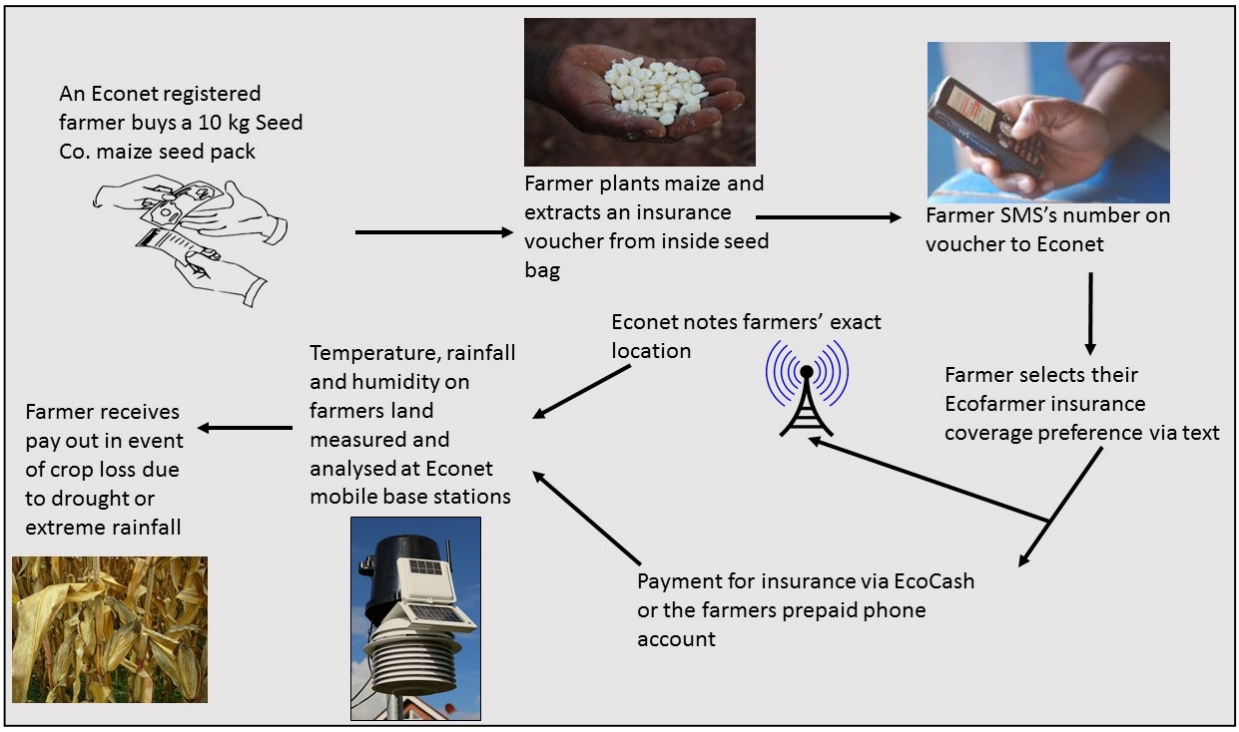


**Figure C6.6.** Conceptual diagram indicating how WIBI is provided to EcoNet's Insured Farmers[195]

Once registered, EcoNet records the exact location of a farmer. From this information, EcoNet's base weather stations can monitor rainfall, temperature and humidity in the area around the Insured Farmer. This information is analysed and collated by scientists and used as the basis to determine if the Insured Farmer is eligible for a pay-out[196].

*Real benefits*

- Over 200,000 clients have opted into the EcoFarmer platform.
- Almost 30,000 farmers have been profiled to receive daily farming tips, weather updates and market prices, with ~60% of these adopting farming methods sent by phone.
- 1,100 farmers were covered by the weather index insurance in the 2013–2014 agricultural season.
- The service has been noted as positively impacting smallholder farmers' farming practices and behaviour.
- The opportunity to access timely and relevant information has provided a foundation for the smallholder farmers to improve their livelihoods.

*Scaling-up potential of EcoFarmer initiatives*

EcoFarmer was initially launched in Mashonaland East – a province in the northern region of Zimbabwe – as a pilot project in October 2013. The province was selected as it comprises three of the five agro-ecological zones in Zimbabwe. The pilot phase – which ended in early 2014 – was considered successful by the implementers and donors. Consequently, the decision was taken to expand the

[195] Adapted from: https://www.EcoNet.co.zw/how-to-register-for-EcoFarmer. Accessed on 29 July 2015.

EcoFarmer project into the neighbouring province of Mashonaland Central in July 2014. The knowledge gathered and lessons learned from the pilot project phase were recorded and allowed EcoFarmer to refine aspects such as pricing structures, technical approaches and distribution strategies for the upscale in Mashonaland Central.

*Relationship with the NHMS*

The implementation of EcoFarmer was reliant on accurate and reliable climate and weather information, particularly timely reporting of potential drought events. Consequently, EcoNet has invested in high-tech weather stations, which are situated at the company's base stations across Zimbabwe. These stations monitor a variety of weather patterns including *inter alia*: i) rainfall; ii) temperature; and iii) humidity. The information collected is collated and analysed by weather experts to determine whether or not a farmer experienced limited or excessive rainfall during an agricultural season[197]. This innovative weather-monitoring network allows the company to determine exactly how much rain fell on the farmer's field at any time.

EcoNet/EcoFarmer's direct relationship with the Zimbabwe Meteorological Service Department (MSD) is unclear. However, information collated and analysed from EcoNet's various weather stations is forwarded to Zimbabwe's MSD, which is poorly equipped[198].

## C6.6 NISCO: Ethiopia

*Background*

Agriculture is the mainstay of Ethiopia's economy, providing employment to ~85% of the population and contributing to ~45% of the country's GDP. The agricultural sector is composed largely of subsistence farmers and rain-fed agriculture is practiced on more than 95% of Ethiopia's farms. Consequently, the agricultural sector – and Ethiopia's economy – is greatly influenced by weather and is susceptible to extreme and unpredictable weather events, such as droughts and floods. As a result, ~10% of the population at risk of chronic food insecurity.

Since 1980, Ethiopia has experienced five national droughts, as well as numerous localised droughts. These droughts have caused crop losses and forced farmers to sell their assets, e.g. plough cattle. Farmers have traditionally used *ex ante* approaches to mitigate against risks associated with adverse weather condition, such as sowing their land with different types of seeds to reduce the risk of crop failure. This approach, however, is largely unsustainable as loss of income through crop failure remains a problem for smallholder farmers.

In order to address these challenges, climate-related services have been piloted in Ethiopia. Following two discontinued pilot projects, Nyala Insurance Company (NISCO), supported by the National Metrology Agency (NMA) and Swiss-Re, introduced crop insurance through "multi-peril crop insurance" (MPCI) and index-weather based insurance[199].

*NISCO's business model*

MPCI insures farmers against both natural and human-related shocks that affect crop yields, including droughts, floods, fire and transit risks. Pay-outs of MPCI occur following two triggers: i) unusual rainfall patterns; and ii) smaller crop yields compared to a pre-agreed benchmark (Figure C6.7). Assessment of localised risk, such as fire and hail, is more costly, and therefore this product is predominantly utilised by commercial farmers.

[197] http://www.newzimbabwe.com/business-16172-Farmers+benefit+from+EcoNets+crop+cover/business.aspx. Accessed on 23 July 2015.
[198] http://venturesafrica.com/EcoFarmer-boosts-zimbabwes-economic-productivity/. Accessed on 27 July 2015.
[199] Nielsen T. 2012. A qualitative assessment of weather indexed crop insurance in Ethiopia. University of Hohenheim, Stuttgart.

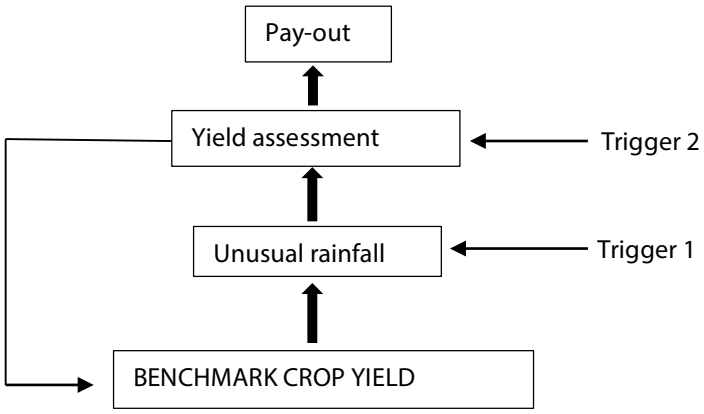


**Figure C6.7.** Simplified conceptual diagram of multi-peril crop insurance.

NISCO's weather index-based insurance (WIBI) is suitable for smalholder farmers in drought-prone areas as it reduces the transaction costs associated with traditional insurance. NISCO's WIBI model is designed according to specific crops. Each crop is divided into three phases: i) initial or vegetative phase; ii) middle or flowering phase; and iii) final or seed formation phase. Each phase is split into ten-day periods, and the amount of rainfall required during each ten-day period is estimated. If there is less rainfall than expected, the deficit is measured in millimetres, and a pay-out is made based on how many millimetres of deficit is recorded[200].

*Real benefits*

In 2009, NISCO piloted WIBI in the Ethiopian district of Boset. This area was chosen because of the following characteristics: i) drought-vulnerable crops; ii) proximity to weather stations; and iii) willingness of local farmer unions to purchase insurance. In total, 137 haricot bean farmers in the Lume-Adama Farmer's Cooperative Union (LAFCU) and 200 teff farmers in the Kola Tenben district purchased insurance[201].

Following a drought in 2009, insured farmers received pay-outs totalling ~US$25,000. Taking into account the total of US$3,550 in premiums collected, NISCO's "investment" generated a considerable profit of ~US$21,000[202].

*Scaling-up potential of NISCO initiatives*

In 2010, NISCO up-scaled its WIBI model to include 1,368 farmers[203], and over the last five years, ~28,000 farmers have been insured through farmers' cooperative unions, micro-finance institutes and other social organisations[204]. There is further potential for upscaling

[200] Meherette, E. 2009. Innovations in insuring the poor: providing weather index and indemnity insurance in Ethiopia. International Food Policy Research Institute, Washington DC.
[201] Meherette, E. 2009. Innovations in insuring the poor: providing weather index and indemnity insurance in Ethiopia. International Food Policy Research Institute, Washington DC.
[202] Balzer, N & Hess, U. 2010. Climate change and weather risk management: evidence from index-based insurance schemes in China and Ethiopia. Revolution: From Food Aid to Food Assistance – instruments 103–123.
[203] Araya NS. 2011. Weather insurance for farmers: experience from Ethiopia. IFAD.
[204] Taddese, B. 2015. Evaluation of the existing rainfall index insurance in Ethiopia's Nyala Insurance Company (NISCO), Ethiopia. In: The challenges of index-based insurance for food security in developing countries, conference paper.

WIBI in Ethiopia, as rural communities perceive climate as a real threat, and are therefore open to new approaches that mitigate against climate-related hazards.

*Relationship with the NHMS*

The success of the NISCO project is largely reliant on reliable weather data. Currently, Ethiopia's National Meteorological Agency has ~900 weather stations, but only ~140 of them have the historical records that are necessary to price index insurance[205]. In addition, the rate of data collection from weather stations is slow. That is, information is recorded manually once a day and disseminated to the central office in Addis Ababa monthly where it is digitised. Consequently, the pilot project was dependent on AWSs that were sponsored by the World Food Programme (WFP) – at a cost of US$3,000 each – to collect data during the insurance contract.

The limited capacity of Ethiopia's NHMS to collect and disseminate climate data is a potential barrier to WIBI. Consequently, private sector investment in Ethiopia's NHMS services will improve the reliability of climate and weather information for insurance purposes, as well as reduce investment in equipment by entities such as WFP.

## C6.7 Malawi Project: Malawi

*Background*

Malawi is a Least Developed Country situated in southern central Africa. Malawi's Human Development Index is ranked 174 out of 187 countries, with ~65% of the population living below the poverty line[206]. Agriculture is the largest sector of the Malawian economy, contributing two thirds to Malawi's ~US$4.3 billion GDP[207]. The agricultural sector employs ~80% of Malawi's population, the majority of whom are smallholder farms. The agricultural sector in Malawi primarily depends on rain-fed crops – including maize, tobacco and groundnut. As a result of its dependence on rainfall, crop production occurs during Malawi's rainy season (December–April)[208]. However, rainfall during this period is erratic and crop failure due to drought is a recurrent problem[209]. Farmers in Malawi are therefore hesitant to invest in improved seed banks and fertiliser as there is a high probability of losing their investment.

Agricultural credit is further limited by the reduced capacity of larger commercial banks to provide loans to smallholder farmers as a result of: i) the large cost of administering these loans; and ii) the perceived great risk of loan defaults[210]. Defaults on loans commonly

[205] Meherette, E. 2009. Innovations in insuring the poor: providing weather index and indemnity insurance in Ethiopia. International Food Policy Research Institute, Washington DC.

[206] Available at: https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CBwQFjAAahUKEwie6dqt8trGAhUzBtsKHV5ABu4&url=https%3A%2F%2Fwww.wmo.int%2Fpages%2Fprog%2Fdra%2Fdocuments%2FCDSCasestudy_DroughtInsuranceinMalawi_withPictures.pdf&ei=3CSlVZ6LI7OM7AbegJnwDg&usg=AFQjCNEjpt_FDQLk7AB-z12lBhCUgClwOA&sig2=WeApAKTsI4QRgRiLWvYAGw. Accessed 14 July 2015

[207] http://data.worldbank.org/country/malawi. Accessed 15 July 2015

[208] https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CBwQFjAAahUKEwie6dqt8trGAhUzBtsKHV5ABu4&url=https%3A%2F%2Fwww.wmo.int%2Fpages%2Fprog%2Fdra%2Fdocuments%2FCDSCasestudy_DroughtInsuranceinMalawi_withPictures.pdf&ei=3CSlVZ6LI7OM7AbegJnwDg&usg=AFQjCNEjpt_FDQLk7AB-z12lBhCUgClwOA&sig2=WeApAKTsI4QRgRiLWvYAGw. Accessed 14 July 2015

[209] https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CBwQFjAAahUKEwie6dqt8trGAhUzBtsKHV5ABu4&url=https%3A%2F%2Fwww.wmo.int%2Fpages%2Fprog%2Fdra%2Fdocuments%2FCDSCasestudy_DroughtInsuranceinMalawi_withPictures.pdf&ei=3CSlVZ6LI7OM7AbegJnwDg&usg=AFQjCNEjpt_FDQLk7AB-z12lBhCUgClwOA&sig2=WeApAKTsI4QRgRiLWvYAGw. Accessed 14 July 2015

[210] https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CEMQFjABahUKEwiqlqO63uvGAhVGmtsKHe6GAJ4&url=http%3A%2F%2Fcapacity4dev.ec.europa.eu%2Fsystem%2Ffiles%2Ffile%2F29%2F01%2F2013_-_0131%2Findex-

occur because of crop failure resulting from unpredictable climate patterns. For example, years of successful lending can be offset by one year of drought. Consequently, famers do not have the means to repay loans, and banks are practically and politically unable to call these loans in[211].

To address the effect of drought on the agriculture sector, the Malawi Project was established. This project was developed through a partnership with the World Bank's Commodity Risk Management Group, Malawi Department of Climate Change and Meteorological Services, as well as the National Smallholder Farmers Association of Malawi (NASFAM) – an umbrella organisation that comprises ~40 local farmers' associations. NASFAM role in the project includes: i) providing access to seed inputs; ii) purchasing the harvests of member farmers; and iii) ensuring loan recovery by deducting the loan and adjusting for any insurance pay-out. In addition, the Malawi Rural Finance Company (MRFC) and Opportunity International Banking Malawi (OIBM) joined the project as loan providers.

*Project Malawi's business model*

The purpose of the Malawi Project was to protect NASFAM-member farmers against the effects of severe drought during the 2005/2006 growing situation. The first insurance policy piloted in Malawi was for groundnut at four different weather stations: Nkotakhota, Kasungu, Kamuzu International Airport, and Chitedze Research Station. The project's model incorporates the three growing stages of groundnut: i) establishment and vegetative growth; ii) flowering and pod formation; and iii) pod filing and maturity (Table 11.7). The model operates on the assumption that the production of the groundnut crop will be reduced when rainfall is lower than a predetermined threshold, or trigger. In the event of a trigger, pay-outs occur. For example, if less than 60 mm falls during the establishment and vegetative growth phase, farmers will be paid ~MWK28 to compensate the farmer for reduced crop production. In addition, the model accounts for the fact that if rainfall is less than a predetermined limit, then crops are unlikely to recover from the water stress. When this occurs, the total sum insured is payable (Table C6.7).

**Table C6.7.** Project Malawi's insurance pay-out model for groundnut farmers during the 2005–2006 growing season

| Growth Period | Days in Growth Period | Trigger (mm) | Limit (mm) | Payout Rate per mm Below Trigger (MWK) | Sum Insured Per Acre (MWK) |
|---|---|---|---|---|---|
| Establishment & Vegetative Growth | 30 | 60 | 30 | 28.5 | 5,701 |
| Flowering & Pod Formation | 50 | 160 | 30 | 16.9 | 5,701 |
| Pod Filling & Maturity | 60 | 100 | 20 | 16.9 | 5,701 |

Before the start of the rainy season, farmers belonging to NASFAM purchased insurance in clubs of 10–20 members. To finance the premiums, clubs entered formal loan agreements with banks. These loans were transferred to NASFAM for the purchase of seeds, and the Insurance Association of Malawi (IAW) to purchase weather insurance premium. Once the crops are harvested, farmers sell their produce to NASFAM at a guaranteed price. NASFAM then sells the produce, with the proceeds of the harvest used to repay the loan. Surplus income is distributed to the farmers.

*Real benefits*

based_insurance_for_smallhomder_farmer_credit_in_malawi.doc&ei=sfmtVer5Lsa07gbujYLwCQ&usg=AFQjCNFhAKhiFa6siRukxNG5vskHfb5pYg&sig2=X9CWZCCuR85I3W05PTA9zw&bvm=bv.98197061,d.ZGU. Accessed 21 July 2015

[211] Available at: https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CEMQFjABahUKEwiqlqO63uvGAhVGmtsKHe6GAJ4&url=http%3A%2F%2Fcapacity4dev.ec.europa.eu%2Fsystem%2Ffiles%2Ffile%2F29%2F01%2F2013_-_0131%2Findex-based_insurance_for_smallhomder_farmer_credit_in_malawi.doc&ei=sfmtVer5Lsa07gbujYLwCQ&usg=AFQjCNFhAKhiFa6siRukxNG5vskHfb5pYg&sig2=X9CWZCCuR85I3W05PTA9zw&bvm=bv.98197061,d.ZGU. Accessed 21 July 2015

The pilot project in 2005/2006 insured 892 farmers located within 20 km of the four weather stations from which climate data was extracted. During the 2006/2007, the project was expanded to 1,710 groundnut farmers and incorporated an additional weather station in Mchinju. In addition, participating farmers were allowed to request credit for maize inputs[212]. Each farmer received: i) US$37 loan for groundnut production inputs; and ii) US$41 loan for maize production inputs. Each loan included costs associated with insurance premiums and interest. These loans enabled farmers to purchase seeds and fertiliser, thereby increasing the quantity and quality of crop yields[213].

*Scaling-up potential*

During the 2007–2008 season, groundnut insurance was halted. Instead, due to the high demand for inputs, the project focused on providing credit to the tobacco sector. This shift in focus was also beneficial for the loan institutions because in Malawi, all tobacco is sold through auction. This allowed the lenders to recover their loans directly before farmers received their proceeds from the sale of their products.

Instead of loans being held by individual farmers, insurance for tobacco crops was covered by loans held jointly by a tobacco company and banks. OIBM purchased index-based weather insurance from the Insurance Association of Malawi (IAM) within 30 km of Lilongwe and Kasungu weather stations. In addition, since tobacco is a valuable crop, IAM was able to enter the international reinsurance market for these products for the first time. Consequently, IAM was able to reinsure some of the risk to the international risk markets[214]. As a result of these changes, the insurance programme expanded to include 2,500 farmers with a total transaction value of US$2 million[215].

*Relationship with the NHMS*

The implementation of the project was reliant on accurate and reliable climate and weather information, particularly timely reporting of rainfall. Through the NHMS, data relating to climate and weather – including historical rainfall and evapotranspiration, as well as soil characteristics and agronomic information – was provided.

The reliance of the project on accurate weather data was a point of concern among farmers. This is because pay-outs were determined from one rainfall station that could potentially be up to 20 km away from the farmer. Considering that rainfall is not homogenous across the landscape, some farmers may benefit more from the project then others based on their location and microclimate. Consequently, there is a need for a broader network of weather stations, as well as maintenance of existing weather stations. The poor

212 https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CEMQFjABahUKEwiqlqO63uvGAhVGmtsKHe6GAJ4&url=http%3A%2F%2Fcapacity4dev.ec.europa.eu%2Fsystem%2Ffiles%2Ffile%2F29%2F01%2F2013_-_0131%2Findex-based_insurance_for_smallhomder_farmer_credit_in_malawi.doc&ei=sfmtVer5Lsa07gbujYLwCQ&usg=AFQjCNFhAKhiFa6siRukxNG5vskHfb5pYg&sig2=X9CWZCCuR85l3W05PTA9zw&bvm=bv.98197061,d.ZGU. Accessed 21 July 2015.

213 https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CEMQFjABahUKEwiqlqO63uvGAhVGmtsKHe6GAJ4&url=http%3A%2F%2Fcapacity4dev.ec.europa.eu%2Fsystem%2Ffiles%2Ffile%2F29%2F01%2F2013_-_0131%2Findex-based_insurance_for_smallhomder_farmer_credit_in_malawi.doc&ei=sfmtVer5Lsa07gbujYLwCQ&usg=AFQjCNFhAKhiFa6siRukxNG5vskHfb5pYg&sig2=X9CWZCCuR85l3W05PTA9zw&bvm=bv.98197061,d.ZGU. Accessed 21 July 2015.

214 https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CEMQFjABahUKEwiqlqO63uvGAhVGmtsKHe6GAJ4&url=http%3A%2F%2Fcapacity4dev.ec.europa.eu%2Fsystem%2Ffiles%2Ffile%2F29%2F01%2F2013_-_0131%2Findex-based_insurance_for_smallhomder_farmer_credit_in_malawi.doc&ei=sfmtVer5Lsa07gbujYLwCQ&usg=AFQjCNFhAKhiFa6siRukxNG5vskHfb5pYg&sig2=X9CWZCCuR85l3W05PTA9zw&bvm=bv.98197061,d.ZGU. Accessed 21 July 2015.

215 https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CBwQFjAAahUKEwie6dqt8trGAhUzBtsKHV5ABu4&url=https%3A%2F%2Fwww.wmo.int%2Fpages%2Fprog%2Fdra%2Fdocuments%2FCDSCasestudy_DroughtInsuranceinMalawi_withPictures.pdf&ei=3CSlVZ6LI7OM7AbegJnwDg&usg=AFQjCNEjpt_FDQLk7AB-z12lBhCUgClwOA&sig2=WeApAKTsI4QRgRiLWvYAGw. Accessed 14 July 2015.

distribution automated or reliable weather stations are therefore a limiting factor to upscaling insurance projects in Malawi. For example, ~110,000 smallholder tobacco farms are currently located close to a reliable meteorological weather station. This could be scaled up to include an additional 200,000 farmers if 53 new rain gauges were fitted[216]. There are, however, limited national funds to invest in weather stations or service existing weather. As a result, through its national development plans, Malawi has prioritised efforts to address its national observatory network.

## C6.8 *WeatherNews*

WeatherNews started trading in 1986 in Japan. Today the company has a staff contingent of more than 700 people and operates in four main regions, namely Japan, Asia, Americas, and Europe. The company's total sales in the 2015 financial year was ~US$140 million. Its business to business income – which is growing at 10.3% per annum – involves three main components, namely: sea; aviation; and land. The sea component, particularly involving voyage planning, is the origin of the business and has a global market share of ~50%. Ports and fishery companies are also major clients. The land component includes the following sub-components: roads, railroads, disaster risk management, dams, rivers, retail, sports events, construction, energy, agriculture and communications. The company's 'business to individual' income has 17 different product lines, and has a strong focus on mobile phone communication. There are subsidiary companies in the USA, Belgium, Australia, Singapore, China, Taiwan, Hong Kong, and Korea, all of which are 100% or almost 100% owned by WeatherNews. The staffing component and revenues per region are: Japan, 612 staff, 1.5% of income; USA, 61, 22%; Europe, 23, 22%; and rest of Asia, 22, 28%. Additional revenue also comes from sales outside of these four regions (but only occasionally from Africa). In the 2015 financial year, gross profit was US$33 million. Importantly, it should be noted that it took three decades to achieve this profit.

Insights emerging from the experience of WeatherNews are that: 1) selling weather information globally is commercially viable for a large company; 2) generating large profits takes many decades of intensive marketing and production of high-quality products; and 3) extreme diversification of markets and products is advisable to hedge bets and enable a slow yet consistent growth of a global weather information company.

216 https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CBwQFjAAahUKEwie6dqt8trGAhUzBtsKHV5ABu4&url=https%3A%2F%2Fwww.wmo.int%2Fpages%2Fprog%2Fdra%2Fdocuments%2FCDSCasestudy_DroughtInsuranceinMalawi_withPictures.pdf&ei=3CSlVZ6LI7OM7AbegJnwDg&usg=AFQjCNEjpt_FDQLk7AB-z12lBhCUgCIwOA&sig2=WeApAKTsI4QRgRiLWvYAGw. Accessed 14 July 2015.

## Annexure C7. Private sector consumers and users of climate and weather information

In addition to the information provided in Chapter 7 on climate-sensitive sectors, Annexure 7 contains detailed descriptions of these sectors, including *inter alia*: i) the factors that cause each sector to be sensitive to climate variations; ii) the existing regulatory framework within each sector; iii) sector-specific climate and weather information requirements; and iv) climate and weather products currently used within each sector.

### C7.1 Aviation

*Background*

Most weather events occur below 5,000 metres above sea level – the airspace that commercial and private airlines use when undertaking the riskiest components of flight, i.e. ascending or descending. Weather events can therefore be a main contributing factor in aviation accidents. Providing accurate and timely information on weather conditions is therefore important in promoting private and commercial flight safety. The anticipated growth of the aviation industry in Africa over the next 20 years[217] will further increase the need to provide enhanced weather information services.

With the exception of government funding, the aviation industry is one of the primary financial contributors to NHMSs in Africa. As a result, many weather stations are located at airports and are dedicated to providing information to aviation authorities. However, generating revenues to cover the NHMSs' costs – particularly from the aviation industries – remains a challenge[218].

*Regulatory framework*

As the risks in aviation can be considerable, the industry is tightly regulated and subject to strict international guidelines and codes of practice. This is necessary to optimise passenger and pilot safety and to meet the requirements of interested or invested parties – e.g. insurers. National aviation industries therefore have an obligation to public safety. In addition to factors related to the aircraft itself, safety involves anticipation and adequate response to weather conditions. Information on weather conditions are provided to the aviation industry – largely by the NHMSs – in accordance with the International Civil Aviation Organisation (ICAO), WMO standards and recommended practices.

The ICAO requires NHMSs to supply operators, aircraft crew, air traffic service units and related aviation stakeholders with meteorological information that meets international air navigation standards. These standards include *inter alia*: i) the establishment of a Quality Management System (QMS) for the provision of aeronautical meteorological services; and ii) ISO 9000 qualifications[219]. In the last few years, African countries have made progress in the implementation of QMSs for the aviation meteorological service and raised the rate of compliance with ICAO requirements to ~60%[220].

As members of ICAO, countries' NHMSs should provide weather forecasts and warnings that are critical to safety. However, the majority of African countries continue to face challenges with effective implementation of Standards and Recommended Practices (SARPs) regarding safety[221,222]. The ICAO therefore has two regional offices in Africa – the Western and Central African (WACAF) office and the Eastern and Southern African (ESAF) Office – that assist member states with establishing and maintaining adequate safety standards in

[217] Tyler, T. International Air Transport Association. At the Aviation day: Connecting Africa: the linkage of regulation, capacity and infrastructure. 23–24 June 2015, Nairobi, Kenya.
[218] Mary Power. Director Resource Mobilization and Development Partnership. AMCOMET meeting 10-11 February 2015, Cabo Verde.
[219] ISO 9000 stands for International Standard Organisation, which provides guidance to develop a quality management system complying with this standard.
[220] Mr D. Ivanov. Chief, Aeronautical Meteorology. AMCOMET meeting 12-13 February 2015, Cabo Verde.
[221] ICAO. 2013. State of Global Aviation Safety.
[222] ICAO. 2013. State of Global Aviation Safety.

air travel. In particular, the mandate of these regional offices is to: i) promote the ICAO policies and SARPs in 24 states; ii) closely liaise with the member states, organisations and regional civil aviation entities by providing advice and assistance as required[223]; and iii) provide support and assistance to the Secretariat of the African Civil Aviation Commission (AFCAC), a specialised agency of the African Union (AU) in the field of civil aviation.

*Regional and national frameworks*

In addition to the regional ICAO offices, there are two regional institutions that facilitate the safe development of aviation systems. In East Africa, this is the East African Community Civil Aviation Safety and Security Oversight Agency (CASSOA). In Francophone West Africa, this is the Agency for the Security of Aerial Navigation in Africa and Madagascar (ASECNA). These institutions work closely with the aviation industry in each country to build capacity.

In addition to these regional offices, the African Ministerial Conference on Meteorology (AMCOMET) oversees the use of national funds to assist countries to comply with ICAO requirements. AMCOMET further encourages NHMSs to: i) develop a quality management framework that leads to ISO certification; ii) obtain ISO-9000 certification; and iii) attain and regular verify calibration certificates for the required equipment[224]. In 2015, AMCOMET allocated US$440,000 for[225]: i) developing programmes; ii) supporting NHMSs with the development of strategic plans; and iii) implementing awareness-raising and outreach campaigns. These programmes are funded through voluntary contributions from partners, in particular Norway, Finland, the AUC, the Republic of Kenya, the Republic of Zimbabwe and the WMO. However, at the third AMCOMET meeting it was decided that – as an African enterprise – AMCOMET's operations and programmes must be owned by Africans with requisite financial support being provided by African governments[226]. AMCOMET is currently considering whether to prioritise aeronautical meteorological services as a "win-win" case, whereby tangible benefits are provided by: i) improving the safety of aviation in Africa; and ii) building core capacities for quality and sustainable services within NHMSs[227].

*What are the climate and weather information needs of the aviation industry?*

In 2001, annual weather-related costs for the US aviation sector – including accident damage, injuries, delays and unexpected operating costs – were ~US$3 billion[228]. Weather-related factors therefore have considerable cost implications, both for airlines and their clients[229]. The following weather factors have been identified as negatively affecting the safety and efficiency of the aviation industry:

- *Wind factors* influence the ascending and descending of aeroplanes. These factors include *inter alia*: i) extreme wind speeds, which delay the departure of aircrafts and prevent aircrafts from landing at the designated airport; and ii) strong crosswinds, which increase the probability of accidents. In a scenario where two winds move in opposite directions, wind shear – a small whirling mass of air – is created, causing turbulence. Wind shear can have particularly disruptive effects when an aeroplane is close to the ground.
- *Icing* negatively affects steering through the slow build-up of ice on the outside surface of the aeroplane.

[223] This includes inter alia to establish and maintain a coordinated and high performance air navigation system aiming at a safe, orderly and efficient air transport system.
[224] WMO & AMCOMET. 2012. Integrated African Strategy on Meteorological Services.
[225] http://www.wmo.int/amcomet/sites/default/files/field/doc/events/annex_10_doc.16_approved_budget_en.pdf. Accessed on 18 August 2015.
[226] Dr. Joseph Mukabana. Director of AMCOMET Secretariat. Third AMCOMET meeting 10-11 February 2015, Cabo Verde.
[227] Mr Ivanov. 2015. AMCOMET meeting 13-14 February, Cabo Verde.
[228] Kulesa G. 2002. Weather and Aviation: How Does Weather Affect the Safety and Operations of Airports and Aviation, and How Does FAA Work to Manage Weather-Related Effects? The Potential Impacts of Climate Change on Transportation Workshop, October 1-2, 2002, DOT Centre for Climate Change and Environmental Forecasting.
[229] Koetse, M.J. and Rietveld, P. 2009. The impact of climate change on weather and transport: An overview of empirical findings. Transport research Part D 14 205–221.

- *Fog and rain* can hamper a pilot's visibility. Daily flight cancellations/delays increase by a factor of 2–3 during fog and rain events in the morning, and by a factor of 3–4 if these events continue throughout the day[230].
- *Lightning* has a considerable effect on aeroplane safety. When lightning is detected, the crew is likely to request a deviation from the planned route. Although rerouting may cause delays, the cost and safety implications for lightning strikes to the aircraft – resulting in severe damage to sensitive equipment on board – exceeds the cost associated with this delay. As is common with fog and rain, lightning can also occur in localised areas and over narrow timeframes. Consequently, it is important that in areas where lightning poses a considerable risk to safety, weather information has high resolution both spatially and temporally.

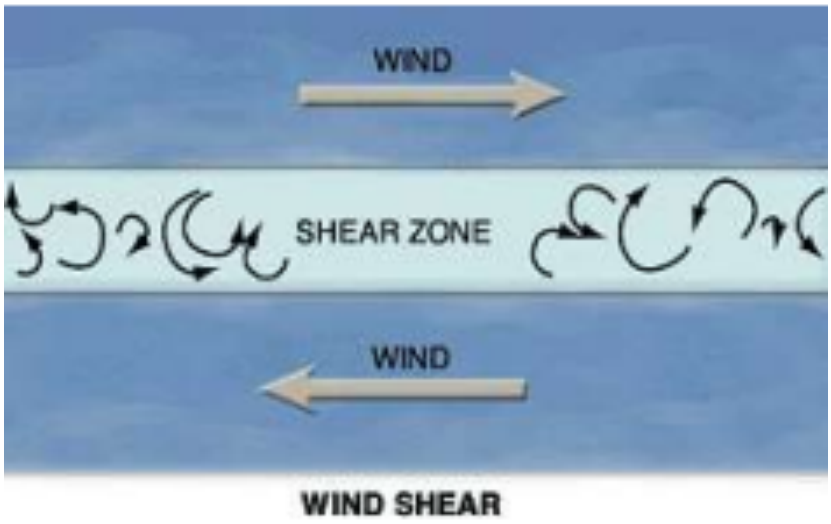


**Figure C7.1.** Wind shear. Air currents of differing velocities create friction or "shear" between them.

*What are the climate products used by the aviation sector?*

To obtain specific information on a flight route to an airport or airstrip, a pilot needs tailored weather information. There are several types of weather data being provided in Africa, including from private weather companies – such as Africa Weather – or intermediaries such as Pilotfriend (see Chapter 6). These companies deliver weather information in tailored packages for pilots that include *inter alia*: i) weather synopsis; ii) sky conditions; and iii) visibility and general weather conditions along the flight path. In addition, tailored packages may include adverse conditions, altimeter settings, cloud tops, wind speed and direction, temperature and precipitation.

The following reports are used by pilots to obtain weather information and assist pilots with determining the feasibility of a flight[231].

- **Meteorological Aviation Routine reports (METAR**) are weather reports mostly provided in the form of raw data, derived from airports or permanent weather stations. The reports are usually generated every 30 minutes. The METAR code is regulated by the WMO in collaboration with the ICAO.
- **Terminal Airport Forecast (TAF)** reports are valid for 24 hours and are issued every six hours for major civic airports and every three hours for military airfields. Because these reports are produced with a strong focus on localised conditions, TAFs are regarded as more accurate than climate service products that have a regional focus. In addition, TAF complements and uses a similar coding system to METAR reports. The weather forecasters responsible for the TAFs in their respective areas are employed by the NHMS.

[230] Eads GC, M Kieferet al. 2000. Reducing weather related delays and cancellations at San Francisco International airport. CRA Report No. D01868-00.
[231] http://www.pilotfriend.com/training/flight_training/communication/weather_data.htm. Accessed on 14 August 2015.

- **Surface Area (SA)**: is a concise overview of the surface weather of an airport weather station or other weather facilities. This report can include up to 10 separate variables such as visibility, sea-level pressure, time and type of report, temperature at dew point.
- **Pilot Reports (PIREPs)** describes the weather conditions experienced by pilots during a flight. Pilots are encouraged to produce these reports as they keep weather information updated and assist in warning pilots in pre-flight of potential weather hazards along their planned route.
- **Terminal Forecast (TF)** predicts the weather at a particular airport (terminal). These forecast predictions cover an area within 5 nautical miles of the centre of the runway field. FTs are usually issued three times a day and are accurate for up to 24 hours.

As a result of greater incomes and population growth over time, the daily number of flights in Africa is increasing. Consequently, there is greater demand for weather information services than ever before. These weather information services are generally pre-recorded and pilots phone an automated system to get preliminary weather information. Based on this information, a pilot will determine if there is a need to speak to a personal briefer. This briefer then provides more detailed weather information necessary to ensure a safe flight. There are several automated systems available. For example, the Pilots Automatic Telephone Weather Answering Service (PATWAS) provides a continuous weather recording with a summary of weather data for an area within 50 nautical miles of a weather station.

Aircraft Communications Addressing and Reporting Systems (ACARS) and electronic flight bags are new systems which are widely used by airlines. These enable pilots to access minute-by-minute updates of weather data to weather services while in flight. Major airlines and weather service providers have already established agreements for aircrafts to provide in-flight weather updates to the weather service provider networks[232].

## C7.2. Agriculture

*Background*

Agriculture is one of the most sensitive sectors to climate and weather[233]. Indeed, climate and weather-related events often lead to considerable crop losses and have been identified as a major barrier for smallholder farmers in developing countries. For example, by 2100, the financial losses resulting from the negative effects of climate and weather-related events in the agriculture sector are expected to be ~3% of GDP in Western and Central Africa and ~1% in Southern Africa[234]. Considering that ~75% of the rural population in Africa depends on agricultural activities for their livelihoods, damage to crops has considerable implications for these individuals. Not only do smaller crop yields decrease farmer's income and food security, they also reduce the willingness of farmers to invest in agricultural inputs – including equipment that is more efficient and better quality seeds. This ultimately limits productivity and the opportunity to improve livelihoods[235].

In the last decade, the agricultural sector has been recognised by economists and politicians as a driver for economic development in Africa, with the greatest potential to reduce inequality and poverty. Improved provision and dissemination of weather information to farmers is therefore necessary to increase productivity and improve livelihoods. Since African women constitute ~70% of the agricultural workforce, their participation and empowerment is important to increase food production and security[236]. Consequently, the effective dissemination of weather products and services requires consideration of gender.

*Regulatory framework*

[232] Willie Saayman, South African Airways manager on duty, UNDP-workshop, Kampala, Uganda 4 March 2015.
[233] NEPAD. 2013. Agriculture in Africa: transformation and outlook.
[234] FAO. 2010. FAO Regional Strategic Framework for Africa.
[235] www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015.
[236] NEPAD. 2013. Agriculture in Africa: transformation and outlook.

In 2006, a Policy Framework for Investment (PFI) was developed by the Organisation for Economic Co-operation and Development (OECD) to support private investment for sustainable development. The PFI can be adapted to different sectors, and a policy framework has been developed for the agriculture sector. The framework is intended to be a flexible instrument for governments to use in evaluating and designing policies for agricultural investment in Africa. Moreover, the framework could assist African governments in their efforts to increase the quantity and quality of investment in support of national development objectives[237]. The framework provides guidance for governments in the form of questions and annotations in nine policy areas, including *inter alia*: i) investment promotion and facilitation; ii) human resource skills and development; iii) trade policy; iv) environment; and v) infrastructure development.

*What are the climate and weather information needs of the agricultural industry?*

Recent surveys in East Africa have indicated that farmers would like to receive the weather information over three time scales[238]: i) historical – using data generated long before the season; ii) seasonal – forecasts using data generated before the season; and iii) short-term – forecasts using data generated during a season. In particular, the following information is needed by farmers over these time scales:

- the onset of seasonal rainfall;
- the expected total rainfall;
- the end of the raining season; and
- the probability of extreme weather events.

The report indicated that the requirements for weather information differed considerably between men and women. For example, the priority weather information for ~80% of the women surveyed is a forecast of expected rainfall over the season and ~55% of woman prioritised a forecast that indicates the onset of the rains. In contrast, ~60% of men surveyed ranked a forecast of the onset of the rains as a first priority and ~55% ranked a forecast of expected rainfall over the season as second priority. This difference in priorities is a result of the different roles men and women have in the sowing, planting and harvesting of crops[239].

In addition to differences in climate and weather information needs, there is a difference in preference for products and services between men and women.

## C7.3 Mobile phone platforms

*Background*

Mobile phones are increasingly being used to disseminate information in a timely manner, since the construction of cell phone towers has made this technology accessible to local communities – even in remote locations in Africa. Recognising the widespread availability of these mobile platforms, many NHMSs and private weather companies are collaborating with mobile phone companies to provide information about predicated weather conditions to local communities. However, in areas with diverse topography, the weather conditions of two locations ~50 km apart may be considerably different. Therefore, to provide an accurate forecast to local communities – and particularly farmers – the mobile phone provider should aim to tailor information, specific to the precise location of each farm. Mobile Network Operators (MNOs) have the technical capacity to locate their subscribers using a triangulation method – which collects information about the location of three base stations closest to the user. This is particularly useful for farmers in anticipation of severe weather events – such as storms and intense rainfall – that can occur locally.

[237] NEPAD-OECD. 2011. Draft Policy Framework for Investment in Agriculture.
[238] CGIAR, 2014.
[239] Tall A., H. Kaur, J. Hansen and M. Halperin. 2015. Tanzania Summary of Baseline Studies: Country Report for the GFCS Adaptation Program in Africa. CCAFS Working Paper no. 124. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

*Regulatory framework*

Most signatories of the WTO Basic Telecoms Agreement committed to some or all features of a negotiated 'Regulatory Reference Paper'. This paper defines the regulatory principles for the establishment and maintenance of competitive telecommunications markets. There are three different models to regulate competition. These models were developed in countries with liberalised telecommunication markets. Briefly, these models are:

1. A reliance solely on competition law, enforced by the competition authority for all aspects of regulation.
2. A reliance solely on sector-specific rules, which include sector-specific competition rule.
3. Opting for concurrent approach, applying both sector- specific and economy wide regulation.

No African country has adopted model 1, while Uganda has adopted the model 2 and Zambia has adopted model 3[240]. In sub-Saharan Africa, most countries have established a regulatory framework that uses independent regulators to administer fair competition in the telecommunication sector. The regulatory framework incorporates provisions to promote competition and controlling market.

*What are the climate weather information needs of the telecommunication sector?*

The mobile phone industry does not have a direct need for climate and weather information. Rather, it acts as an intermediary between the NHMS and end users and therefore its information needs are determined by end users.

*What are the climate products used by the telecommunication sector?*

Vodacom is working with customers to explore opportunities to develop viable commercial propositions that can benefit farmers, communities and other customers by:

- *Improving access to financial services*. Many mobile phone companies enable mobile money transfer services. For example, Vodacom's' M-Pesa, offers a platform to work with partners to build new financial solutions that are specific to the agricultural sector. M-Pesa improves access to financial services for farmers and fieldworkers, enabling them to exchange, save and borrow small amounts of money, as well as access insurance to cover the cost of replanting if the weather destroys their crops.
- *Providing information to farmers via SMS text and helplines*. Services such as Vodafone Farmers' Club in Turkey include local weather forecasts, crop prices and guidance on topics such as pest control, sustainable agriculture and resource management.
- *Enhancing access to markets*. Online marketplaces enable trading of agricultural product and skills, which can help farmers get better prices for their crops. In Tanzania, Vodacom is partnering with Oxfam to test a mobile marketplace for agricultural produce.
- *Improving supply chain efficiency*. Mobile technology can improve communication between smallholders, distributors and retailers. For example, farmers and field agents can share information with retailers and distributors *via* mobile phones. Distributors can then track and trace the movement of produce and manage their fleets using machine-to-machine (M2M) technology.

These SMS text messaging, mobile payments and M2M services are increasingly enabling farmers and enterprise customers to improve the productivity, efficiency, security and visibility of the agricultural supply chain[241].

## C7.4 Weather-based Index Insurance: status quo

*Background*

Floods and droughts have been recognised as the main climate-related hazards that affect communities in Africa. Indeed, half of the countries in Sub-Saharan region are exposed to at least one drought every seven and a half years. Those Sub-

[240] Alemu, R. 2013. Regulation of Competition in the Liberalised Telecommunications Sector in Sub- Saharan Africa: Uganda's Experience.
[241] https://www.vodacom.co.tz. Accessed 20 July 2015

Saharan countries that are less exposed, still at least one flooding event every three years[242]. Despite these frequent hazards, rural smallholder farmers generally do not implement measures to protect their crops – and resulting income – from these weather shocks[243]. Instead, farmers rely on *ex-post* shock coping and *ex-ante* risk management to reduce the effect of climate-related hazards[244].

To address the effects of climate-related hazards on the agriculture sector, smallholder farmers have begun investing in risk transfer through Weather Index-based Insurance (WIBI). This insurance service has been piloted in several developing countries in Africa[245], with its potential application growing as the negative effects of climate change have become more apparent. These negative effects include changes in average climatic conditions, as well as an increase in the frequency, severity and variability of extreme weather. While in most countries, WIBI is still at a pilot stage or is largely subsidised[246], it has shown to be an effective tool in increasing the resilience of smallholder farmers to extreme weather events and climate change.[247]

*What is WIBI?*

Crop or livestock insurance has traditionally relied on directly quantifying damage or loss of the insured party. However, this form of insurance is often not appropriate for rural, small-scale farmers as access to remote areas by evaluators may not feasible, particularly when the country's insurance markets are underdeveloped[248]. In contrast, WIBI is an insurance package, linked to an index that correlates with local agricultural yields[249]. This approach insures against specific, weather-related events that are recorded at local weather stations[250]. Pay-outs are triggered when the weather-related index reaches a predetermined threshold – for example, minimum rainfall – as opposed to measuring actual crop yields. As a result, evaluator assessments in the field are not necessary and there is no need to customise contracts and both of these factors reduce transaction costs[251]. In addition, because pay-outs are determined by an independently verifiable index, the insurance product can be reinsured – where portions of the risk portfolio are transferred to another insurance company to reduce the likelihood of large pay-outs resulting from an insurance claim[252].

Individuals that are insured in the same area – i.e. are vulnerable to the same weather patterns – pay the same premium and receive the same rate of pay-out[253]. These pay-outs are structured along a continuum that ranges from a simple zero/one contract (for example 100% pay-out rate once the threshold has been crossed), to a layered payment schedule (e.g. a one-third payment rate as different thresholds are crossed), and a proportional payment schedule[254].

*How WIBI works*

WIBI differs from traditional insurance in that the insurance contract is based on an environmental parameter (e.g. rainfall or temperature), where data on the parameter can be collected from a weather station over a predetermined time-period[255].

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242 http://www.povertyactionlab.org/publication/index-based-weather-insurance-developing-countries-review-evidence-and-set-propositions-. Accessed 2 November 2015.

243 http://www.povertyactionlab.org/publication/index-based-weather-insurance-developing-countries-review-evidence-and-set-propositions-. Accessed 2 November 2015.

244 http://www.povertyactionlab.org/publication/index-based-weather-insurance-developing-countries-review-evidence-and-set-propositions-. Accessed 2 November 2015.

245 www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015.

246 https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/IFC_PPCR%20Niger%20Agri%20Insurance_Public_Full_English_23Feb2014.pdf. Accessed 13 August 2015.

247 www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015.

248 www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015.

249 http://www.ifad.org/ruralfinance/pub/weather.pdf. Accessed 28 July 2015.

250 http://www.ifad.org/ruralfinance/pub/weather.pdf. Accessed 28 July 2015.

251 http://www.ifad.org/ruralfinance/pub/weather.pdf. Accessed 28 July 2015.

252 http://www.investopedia.com/terms/r/reinsurance.asp. Accessed 28 July 2015.

253 http://www.ifad.org/ruralfinance/pub/weather.pdf. Accessed 28 July 2015.

254 http://www.ifad.org/ruralfinance/pub/weather.pdf. Accessed 28 July 2015.

255 www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015.

Consequently, the contract requires an accurate model – informed by baseline climate – that correlates temperature and rainfall to crop production. In the absence of an accurate model, an insurance agreement cannot be structured fairly.

WIBI contracts generally consist of the following features: i) a specific meteorological station, or reference station; ii) a weather measurement trigger – e.g. 0.5 mm of rainfall over 3 months – that results in a pay-out, either with a lump sum or incrementally; iii) a limit to the measured parameter, after which a maximum pay-out is made – e.g. 0.2 mm of rainfall over 3 months; and iv) the period over which the insurance agreement is valid. The specific insurance period coincides with the growth period of the crop, and is usually divided into three phases – each with its own trigger and limit[256].

WIBI is not intended to be a "catch-all" solution to crop failure in developing countries. Rather, it is an effective approach to mitigate against climate-related hazards when there is a close correlation between the hazard and crop yield. This correlation is strongest when there is a single crop, a designated rainy season and no irrigation. The WIBI model does not account for multiple risks, such as pests and disease. In addition, WIBI is not suitable when there are different microclimates (e.g. mountains) or localised risks (e.g. hail). Because of these limitations, most WIBI contracts – such as the R4 Initiative in Ethiopia (see Chapter 3) – have focused on the risk of drought[257]. This initiative also innovated the WIBI model by packaging insurance with financial services. This packaging promoted participation in the programme by rural communities and resulted in its upscaling[258].

*Stakeholders*

Introducing WIBI to developing countries requires participation from multiple stakeholders – including insurers, the NHMS, government, as well as distribution and support agencies. While WIBI operates on market-based principles and business practices, partnerships between the private and public sector are common.[259]. Co-ordination among public and private agencies is necessary in decreasing legislative bottlenecks and reducing the pay-out period[260].

Insured parties

These stakeholders are policyholders – specifically farmers, households or small-business owners – who purchase insurance to protect themselves from the negative effect of unpredictable weather patterns. These policies are often distributed to individuals through intermediary organisations. These organisations – including farmers' associations[261], input suppliers[262] or NGOs[263] – are effective as they: i) access a large target group; ii) reduce transaction costs; and iii) have direct interest in protecting farmers against adverse weather conditions. In addition, through the involvement of intermediary organisations, the risk of default by farmers can be managed. Consequently, intermediary organisations can facilitate farmers' access to high-quality inputs and credit, both of which will support their productivity[264].

Premiums charged to farmers for insurance against low rainfall is generally 8–10% of the sum that has been insured, including administrative costs[265]. These charges are usually affordable to the client, particularly when the contracts include high-quality inputs and credit[266]. Indeed, the sale of an insurance contract is normally bundled with farming inputs or microfinance credit[267]. Affordable premiums mean that WIBI can be purchased by many smallholder farmers. As a result, farmers can protect their investment in crops and escape the cycle of poverty resulting from the negative effect of unpredictable weather conditions on crop production[268].

256 www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015.
257 www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015.
258 https://www.agriskmanagementforum.org/content/what-r4-initiative. Accessed 2 November 2015.
259 www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015.
260 http://www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 11 August 2015.
261 http://www.gfdrr.org/sites/gfdrr.org/files/documents/DRFI_Malawi_WeatherInsurance_Jan11.pdf .Accessed 2 November 2015.
262 AGRA in 2012: Moving from Strength to Strength. Nairobi, Kenya: Alliance for a Green Revolution in Africa (AGRA). 2013
263 http://www.wfp.org/stories/weather-index-insurance-powerful-tool-against-hunger. Accessed 2 November 2015.
264 www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015
265 https://sustainabledevelopment.un.org/content/documents/no2.pdf. Accessed 28 July 2015.
266 https://sustainabledevelopment.un.org/content/documents/no2.pdf. Accessed 28 July 2015.
267 http://www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 17 August 2015.
268 www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015

Previous pilot projects in Africa have produced in best practice guidelines that will promote the success of WIBI in developing countries. These lessons include: i) ensuring timely pay-outs to farmers to foster trust and promote continued use of the insurance services; ii) promoting the use of modern technologies in rural agricultural practices; iii) ensuring that the rules and regulations of an insurance contract are accurately conveyed to farmers[269]; iv) promoting farmer participation in insurance products by bundling loans in the insurance package; and v) investing in reinsurance to prevent large pay-outs by the insurance company.

Private and public sector

Initiatives that focus on climate change adaption in rural communities often rely on private sector investment to: i) mobilise financial resources and technical capacity; ii) leverage the efforts of government; iii) support the efforts civil society and community organisations; and iv) develop innovative climate services and adaptation technologies [270].

Private initiatives require support from the public sector for information, supportive policies and regulation[271]. To encourage private sector investment in WIBI initiatives, the policy and regulatory environment must therefore be considered fair, credible, stable and enforceable[272]. The overarching goal of these partnerships in developing countries is to promote the generation of reliable climate and weather information for end users, while reducing costs for the country[273].

The model in Figure C7.2 describes entry points for both the private and public sector in WIBI initiatives.

The insurance company (1.) is generally a profit-generating organisation that provides a product through a distribution channel (4.) that goes either directly to the end user (i.e. farmer; 2.), or through an intermediary organisation (3.). Intermediary organisations – including farmers' associations, input suppliers or NGOs – have been found to be highly effective for on-the-ground service delivery and ensuring that premiums are paid.

The insurance company often transfers portions of its risk portfolio to an international insurance company through reinsurance (6.). In addition to acting as product providers, the private sector can be involved in WIBI initiatives by providing and maintaining automated weather stations to generate weather data (5.) – a key component in promoting the success of WIBI projects – but is often beyond the capacity of the public sector in developing countries as a result of limited financial capacity and technical expertise.

The public sector supports WIBI initiatives by subsidising farmer premiums, which are often too expensive for smallholder households to afford. In addition, the countries NHMS is imbedded within the government and is responsible for collecting and packaging weather data.

[269] This requires investment in training by insurance companies which is generally not reflected in insurance premiums.

[270] http://reliefweb.int/sites/reliefweb.int/files/resources/Biagini+and+Miller+Engaging+the+Private+Sector+in+Adaptation+to+Climate+Change[1].pdf. Accessed 22 July 2015.

[271] http://reliefweb.int/sites/reliefweb.int/files/resources/Biagini+and+Miller+Engaging+the+Private+Sector+in+Adaptation+to+Climate+Change[1].pdf. Accessed 28 July 2015.

[272] https://books.google.co.za/books?id=3SRYgoxaG_gC&pg=PA9-IA7&lpg=PA9-IA7&dq=model+for+private+sector+investment+in+weather+based+index+insurance&source=bl&ots=RLkBCY6OMD&sig=PUEe0EbiXAC4uL2H6qHyoC3naQc&hl=en&sa=X&ved=0CCYQ6AEwAmoVChMIkbWvp4CjxwIV7RfbCh0gYgFp#v=onepage&q=model%20for%20private%20sector%20investment%20in%20weather%20based%20index%20insurance&f=false. Accessed 18 August 2015.

[273] http://reliefweb.int/sites/reliefweb.int/files/resources/Biagini+and+Miller+Engaging+the+Private+Sector+in+Adaptation+to+Climate+Change[1].pdf. Accessed 17 August 2015.

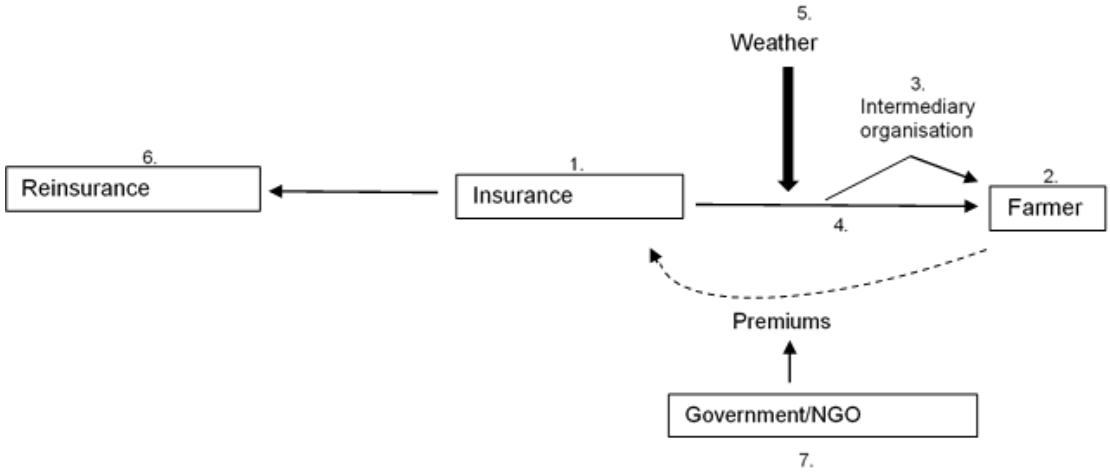


**Figure C7.2.** Private and public sector involvement in WIBI initiatives.

*Relationship with the NHMS*

The function of NHMSs is to "contribute to the economic, social and environmental benefit and welfare of their national communities through the provision of meteorological and related science and services"[274]. However, NHMSs in many developing countries in Africa have limited financial support and technical capacity to generate climate and weather data for large areas at a fine scale. This reduces the potential for WIBI in many developing countries. In recognition of these limitations, the African Ministerial Conference on Meteorology (AMCOMET) was established in 2010 to promote the development of meteorology and its application in Africa, thereby supporting socio-economic development of African countries (see Chapter 3). Through the establishment of AMCOMET, the African Strategy on Meteorology (climate services) was developed in partnership with the WMO. The priority interventions identified in this strategy focus on promoting the production and incorporation of science-based climate and weather information and services into African development policy, planning and programmes[275]. Private sector investment and demand from the private sector for climate services will help operationalise services provided by the NHMS. Identifying potential private partnerships in relevant sectors – including agricultural, insurance, transport and tourism – is likely to catalyse improvements in NHMSs.

*Upscaling*

Currently, opportunities for upscaling WIBI has been limited in Africa. Initiatives that expanded beyond pilot phase were either free, heavily subsidised, or packaged with additional benefits, such as credit and technical assistance[276]. A 2010 meta-analysis of 36 WIBI case studies concluded that the upscaling potential of WIBI pilot projects would benefit from the following: i) adding value of the insurance policy by packaging credit and inputs, for example; ii) building the capacity and ownership of stakeholders; iii) increasing the awareness of farmers of WIBI; iv) engaging the private sector to promote investment in data-generating weather services; v) accessing international risk markets; vi) improving weather station equipment and thereby the data generated from these weather stations; vii) promoting enabling regulatory frameworks; and viii) continuously monitoring and evaluating services to guide iterative improvements.[277]

Opportunities for upscaling WIBI projects are generally constrained by insured parties. Smallholder farmers in rural locations often have limited financial literacy and there is no established trust in financial institutions. Moreover, it is challenging for smallholder farmers to perceive the value of an insurance product as it is an intangible asset. In addition, even when markets are well developed, the per

[274] Zillman, J. W. The Role of National Meteorological Services in the Provision of Public Weather Services
[275] African Ministerial Conference on Meteorology (AMCOMET) investing in climate and weather services for development. Integrated African Strategy on Meteorology (climate and weather services)
[276] Carter, M., de Janvry, A., Sadoulet, E. and Sarris, A. 2014. Index-based weather insurance for developing countries: A review of evidence and a set of propositions for up-scaling.
[277] www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015.

capita value for each insurance contract is generally small and servicing costs are large. Providing coverage of products like WIBI over a large scale is therefore challenging.

To improve farmer participation in WIBI initiatives, the following basic requirements should be identified: i) interventions to be maintained throughout the implementation period; ii) training on financial literacy to be provided to farmers; iii) community leaders and trusted local partners to be involved in distribution of insurance products; iv) WIBI contracts to be packaged with additional purchases such as inputs and marketing; and v) risk-sharing arrangements from public or private institutions[278].

Additional factors to promote the success and upscaling of WIBI interventions[279] include *inter alia:*

1. *Insurance that increases farmer income*. By having access to insurance products that create opportunities for smallholder farmers to increase productivity – and thereby income – farmers are more likely to invest their income in insurance products.
2. *Holistic approaches*. Index-based insurance is most effective when it is incorporated into broader programmes for development and climate risk management. In many case studies, the index insurance was designed around a weather-related parameter (e.g. drought), and complemented by other risk management approaches that addresses more frequent, less severe events. Studies have also shown that demand for insurance increased when it was packaged with additional risk management strategies, including bundling tools such as credit or improved inputs.
3. *Farmer-driven design*. The success of WIBI initiatives have been enhanced when farmers have been included in the design of the insurance product. This approach allows the risk to crops to be determined in a transparent and accurate manner and has also been shown to be an important aspect in promoting upscaling initiatives.
4. *Building trust and capacity*. An overarching limitation to the success of WIBI initiatives is a lack of trust by farmers in insurance schemes, wherein farmers are made to pay premiums now and are promised a payment later. Consequently, partnering with established local organisations is an important approach to building trust within communities. Similarly, increasing farmers' understanding of insurance products through training and capacity building is important in generating demand.
5. *Developing markets, supply chains and logistical support systems*. Successful implementation of WIBI initiatives involved collaboration with policy makers, market leaders and the private sector to develop supply chains and legislative frameworks. This enables initiatives to be upscaled without being impeded by barriers associated with national regulations.
6. *Solid science, technology and basis risk*. WIBI initiatives depend on weather data that is accurate, robust and scientific. This entails collaborating with research organisations to consolidate agro-meteorological data to quantify basic risk and social science research. This will promote communication with farmers.

## C7.5 Fisheries

*Background*

An increase in the frequency and severity of adverse weather events and natural disasters are threatening the lives of inland and marine fishermen. The types of disasters that affect the fishing industry include natural disasters such as: i) storms, cyclones or hurricanes, with associated flooding and tidal surges; ii) tsunamis; iii) earthquakes; iv) droughts; v) floods; and vi) landslides. Indirectly, severe weather can affect the fisheries' infrastructure harbours, thereby damaging equipment, landing sites and processing facilities[280]. Moreover, the effects of climate change – including sea-level rise and extreme weather events, such as floods and increased storm severity – will affect productive coastal habitats that support fishing activities, fish farms and income-generating assets[281]. The frequency and intensity of these extreme weather events are expected to increase as a result of climate change.

[278] www.ifad.org/ruralfinance/pub/wii_tech_guide.pdf. Accessed 22 July 2015.
[279] Greatrex, H. Hansen, J. Garvin, S. Diro, R. Blakeley, S. Le Guen, M, Rao, K and Osgood, D. 2015. Scaling up index insurance for smallholder farmers: recent evidence and insights. Research Program on Climate Change, Agriculture and Food Security.
[280] Mohammed, E.Y. and Uraguchi, Z.B. 2013. Impacts of climate change on Fisheries: Implications for food security in Sub-Saharan Africa. In Global Food Security.
[281] Allison. 2005. Effects of climate change on the sustainability of capture and enhancement fisheries important to the poor: analysis of the vulnerability and adaptability of fisher folk living in poverty. Fisheries Management Science Programme Department for International Development, DFID: 167p.

The financial costs to the fishery industry in Africa as a result of adverse weather events and the effects of climate change is estimated at ~US$311 million[282]. This is because fishermen in many African countries do not have adequate access to timely weather information, thereby reducing their capacity to protect their assets from extreme weather events. The provision and dissemination of timely weather information will therefore enable fishermen to make informed decisions about when and where to fish and consequently increase their personal safety and livelihood productivity.

*Regulatory framework*

The main regulatory frameworks on climate, weather and fisheries are the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) and Joint Commission for Agricultural Meteorology (CAgM), as part of the WMO.

The CAgM's priorities are to: i) develop enhanced services for agriculture, livestock, forestry, rangelands and fisheries communities, including agricultural meteorological consulting services; ii) engage with the Agriculture and Food Security exemplar of the Global Framework for Climate Services; iii) promote development of a knowledge-sharing interface between forecasters/scientists, extension services and the agricultural decision-makers; and iv) identify the agrometeorological information needs of vulnerable communities to support the development of tailored agrometeorological products and services.

The JCOMM coordinates activities and develops and recommends standards and procedures for services for related to marine climate observation and data management. The long-term objective of the JCOMM is to coordinate the development and delivery of climate services related to the marine atmosphere and coastal and deep oceans. These services are based on the core competencies within the Commission in Marine Meteorology and Oceanography, as a contribution to the GFCS.[283]

In 2013, the Joint CAgM-JCOMM Task Team on Weather, Climate and Fisheries was established. The terms of reference for this Task Team are to:

- assess how data collected by JCOMM and others meet the current needs of the ecosystem approach to manage fisheries and develop climate services;
- encourage oceanic and coastal fisheries management organisations to inform their members about the advantages of reporting relevant marine meteorological and ocean observations to various WMO/IOC observation and information systems;
- contribute to the understanding of the effects of climate and climate variability – at seasonal and decadal time scales – on fisheries and marine aquaculture;
- contribute to the understanding of the impacts of climate change on fisheries and marine aquaculture;
- identify risk assessment or management evaluation tools that incorporate climate variability to improve the ecosystem approach to managing fisheries;
- identify how climate and weather tools can inform integrated coastal zone management relevant to coastal fisheries and marine aquaculture.

*Regional and national frameworks*

In 2010, the Conference of African Ministers of Fisheries & Aquaculture (CAMFA) was established by the African Union. The conference has the following objectives: i) identify clear, evidence-based priorities for the development of fisheries and aquaculture; ii) agree on strategies to scale up best practices in fisheries and aquaculture development in Africa within the Comprehensive Africa Agricultural Development Programme (CAADP) framework; and iii) determine the strategies for supporting fisheries governance and policy reforms that are necessary to improve the role of sustainable fisheries in contributing to African countries' economies and welfare.

[282] http://www.climatechangenews.com/2014/03/25/climate-change-could-devastate-africa-crop-yields/. Accessed 30 August 2015.
[283] http://www.wmo.int/pages/prog/amp/mmop/jcomm_partnership_en.html. Accessed on 30 September 2015.

The CAMFA is supported by the Partnership for African Fisheries (PAF). This partnership promotes the reform of policy within African fisheries and aims to ensure that this process is guided by sound advice. PAF is a programme of the New Partnership for Africa's Development (NEPAD). The main objective of the PAF is to improve the contribution of African fisheries to sustainable growth of the fisheries sector. This will be achieved by: i) developing a Comprehensive African Fisheries Reform Strategy to guide national, regional and international fishery policy reform; ii) understanding and sharing the potential benefits of African fisheries to promote economic and social growth; iii) increasing and sharing knowledge and experience of tools, systems and policy requirements to address illegal fisheries production and trade; and iv) exploring and exchanging innovative and equitable approaches to investment and trade in African fishery products.

NEPAD and the FAO developed the joint NEPAD-FAO Fish Programme[284] to *inter alia* assist with the incorporation of adaptation to climate change (CCA) and Disaster Risk Management (DRM) into fisheries governance. This approach entails focusing on the need to develop and integrate CCA and DRM plans into fisheries and aquaculture strategies at local, national and regional levels.

The limited policy coherence and coordination in the management of fisheries and aquaculture resources in the AU countries remains a challenge. To address this challenge, the African fisheries policy framework and reform strategy was established in 2014. The objective of this framework is to facilitate coherent policy development for the sustainable management of fisheries and aquaculture resources in member states of the African union. In addition to promoting the sustainable development of fisheries and improved coordination between states, the framework considers the predicted effects of climate change and the increased occurrence of disasters that affect the fisheries sector.

Regional committees have been established to coordinate the implementation of the aforementioned policies and frameworks. The committees below are the most relevant for the countries supported by the CIRDA programme.

East Africa

The **Lake Victoria Fisheries Organisation (LVFO)** – comprising the fishery commissions of Kenya, Tanzania and Uganda – is responsible for coordinating and managing fisheries resources in Lake Victoria. The management structure of the LVFO consists of a Council of Ministers, Policy Steering Committee, Executive Committee, Fisheries Management Committee, Scientific Committee, Working Groups and Beach Management Units as well as the Secretariat of the LVFO.

West Africa

In 1967, the **Committee for the Eastern Central Atlantic Fisheries (CECAF)** – which includes Benin, the Gambia, Liberia, Sao Tome and Sierra Leone – was established. The objective of this committee is to promote the sustainable use of living marine resources in the Eastern Central Atlantic by establishing appropriate management and development strategies for fisheries and fishing operations. The Committee does not have regulatory powers but can adopt recommendations on management issues.

Established in 1971, the **Committee for Inland Fisheries and Aquaculture of Africa**– which includes Benin, Burkina Faso, the Gambia and Sierra Leone – has the objective of promoting the sustainable development of inland fisheries and aquaculture in Africa.

**The Ministerial Conference on Fisheries Cooperation among African States Bordering the Atlantic Ocean (COMHAFAT)** was established in 1989 and includes Benin, the Gambia, Liberia, Sierra Leone and Sao Tome and Principe among its 22 members. COMHAFAT covers all living marine resources within its area of competence. The main objectives of COMHAFAT are to *inter alia*: i)

[284] The overall objective of the NFFP is to develop capacities for improving governance, in particular at the regional and sub-regional levels, while at the same time supporting local and national level efforts with regard to responsible fisheries and social and economic development. The Programme consists of three components: i) enhanced multi-level governance, policy coherence and economic integration; ii) improved management through the EAF/EAA; and iii) reduction of vulnerability through DRM and CCA, as well as cross-cutting issues, such as gender.

promote active and organised co-operation of fisheries management and development in the region; and ii) promote food self-sufficiency through the rational utilisation of fishery resources. The functions of the COMHAFAT include the assessment and conservation of migratory species, as well as the maintenance of the maritime data.

*What are the climate and weather information needs of the fishery sector?*

The following information categories have been identified as necessary for the fishery sector:

- Information on **rainfall** patterns and volume is needed, as they affect the probability of baiting a fish. That is, during or shortly after light rains, insects fly close to the water surface, which encourages fish to hunt closer to the surface. This foraging activity also occurs because rainfall often increases the amount of organic matter in the water, thereby attracting fish to the surface to forage.
- Monitoring **wind direction** and **wind speed** is important for the safety of fisherman. These factors determine how far out fishermen can go to fish before their safety is compromised.
- **Upwellings** influence the probability of fish coming up to the surface. Coastal upwellings are wind-driven masses of cold, nutrient-rich waters replacing nutrient-poor surface warm waters. A reduction or variation in upwellings may seriously affect the fisheries sector[285].
- **Water temperature** influences the type of fish species that are caught. In particular, an increase in the temperature of seawater as a result of climate change will adversely affect coral reefs and thus fish catch yields.
- **Tidal patterns** determine the area where fish amass. During high tide, fish are provided with new feeding areas. During low tide, fish are forced into waterlogged holes where they are easy to catch[286].
- **Air pressure** influences fish activity. Fish are sensitive to changes in pressure and will often increase their activity just before a cold front. Under these conditions, fish can be easily caught. In addition, before a cold front, air bubbles are released in the water. These bubbles can transport small particles and organisms up to the surface, bringing fish up to forage[287]. In contrast, in high-pressure systems that emerges following a cold front, fish that are less likely to feed.

*What climate products are used by the fishery sector?*

There are two types of fisheries: i) fresh water or inland – i.e. lakes and rivers; and ii) marine – i.e. the ocean. There are different types of climate products available to fishermen, depending on the type of fishery they are engaged with.

Marine

Climate products used in Africa's marine fisheries include *inter alia:*

- **Tide Gauges to monitor sea level change**. The gauges often form part of a global network of tsunami watch stations that monitor abnormal sea level changes resulting from tsunamis. These stations therefore serve as an important input for the early warning of tsunami.
- **Wave rider Buoys** monitor high waves and warn fishermen of changing wave conditions.

East Africa freshwater

Approximately 90% of the fish produced in this region originates from freshwater sources. Lake Victoria is the largest freshwater lake in East Africa, and is therefore important for the transportation of goods and the fisheries industry. To develop smooth and safe operations on the Lake, the timely provisioning of weather forecasts to ships and other vessels is required – particularly as the region around the lake has the greatest occurrence of hailstorms and thunderstorms in the world. On the Tanzania's side of the lake, there are three synoptic stations, one each in Bukoba, Musoma and Mwanza. On the Ugandan side, there are two stations, one each in Jinja and

[285] Badjeck, MC, et al. 2011. Envisioning 2050: Climate Change, Aquaculture and Fisheries in West Africa, Senegal 14-16th April 2010. Workshop Report No. 2011-09. Penang/Bremen: WorldFish/ZMT.
[286] http://www.sightfishing.com/factors.htm. Accessed on 30 September 2015.
[287] AccuWeather Meteorologist Dave Samuhel.

Entebbe. There are no weather observation stations located over the Lake itself. The limited availability of climate and weather data on the Lake and surrounding areas has hindered efforts to effectively use the resources of the lake and the associated basin[288]. To address these limitations, an initiative was developed in 2010 to disseminate weather warnings to fishermen at Lake Victoria in Uganda using an SMS service from a mobile phone company. However, as a result of limited willingness to pay from the mobile phone users and inaccurate weather information from the NHMSs, this service has stopped.

In 2004, there were five land-observing synoptic stations along the coast in Tanzania – located in Tanga, Mtwara, Dar es Salaam, Zanzibar and Pemba, respectively. However, the observation network over the Indian Ocean is not sufficient to provide weather information to fishermen. To address this gap in the observation network, the International Buoy Programme for the Indian Ocean deployed a limited number of drifting and moored buoys within the eastern Indian Ocean. However, the western part of the ocean remains relatively unmonitored. In addition, the forecasts issued by TMA and KMD for the Indian Ocean are not specific, and the means for their dissemination are inadequate. To improve this, an increased network of stations, improved equipment and better forecasting facilities around the Lake and along the Indian Ocean coast are required[289].

West Africa inland freshwater

Currently, no information could be found on the status of weather stations near waterways in West Africa.

## C7.6 Renewable Energy

*Background*

Renewable energy (renewables) is a rapidly growing sector in Africa, particularly wind energy. The African wind energy market was predicted to reach ~1 gW of installed capacity by 2015, piloted initially in South Africa and Egypt, but with capacity in Morocco, Ethiopia, Kenya, Tanzania and Ghana increasing quickly. This growth in renewables presents a long-term opportunity for NHMSs, since accurate wind forecasts are essential for independent power producers to predict daily feed-ins to the national grid. While the exact commitments, accuracy, requirements and financial ramifications differ from one offtake contract to the next – i.e. between different markets – there is generally a requirement to forecast power output. Over-supply is usually not purchased by the national energy company, and under-supply is often penalised; accurate forecasts of wind and insolation are therefore of great financial importance to an independent power producer.

The forecasts provided by NHMSs are not used by independent power producers and the preference is largely to undertake "in-house" forecasting and wind modelling for resource assessment to support development activities in Africa. However, these in-house forecasts are not real-time and therefore cannot be supplemented with NHMS information. This is as a result of the quality of such measurements – NHMS wind data are typically too close to the ground (the nacelle of a 5 mW turbine stands over 120 m above the ground, where wind can be very different from that at 0 m), affected by obstacles and not documented and maintained to a requisite standard for commercial wind-modelling purposes. However, independent power producers may use NHMS data for basic model validation and long-term adjustment of locally measured data of their own.

The opportunity for wind energy is therefore not available for NHMSs, since the gap to fulfil private sector needs is substantial, and already being satisfactorily addressed by the private sector itself. Renewable energy developers in the private sector establish and maintain proprietary wind models that are detailed and have high resolution. Indeed, these models represent a substantial component of their competitive advantage in a capital-intensive and competitive market.

[288] East African Community. 2004. Five Year Meteorological Development Plan and Investment Strategy.
[289] East African Community. 2004. Five Year Meteorological Development Plan and Investment Strategy.

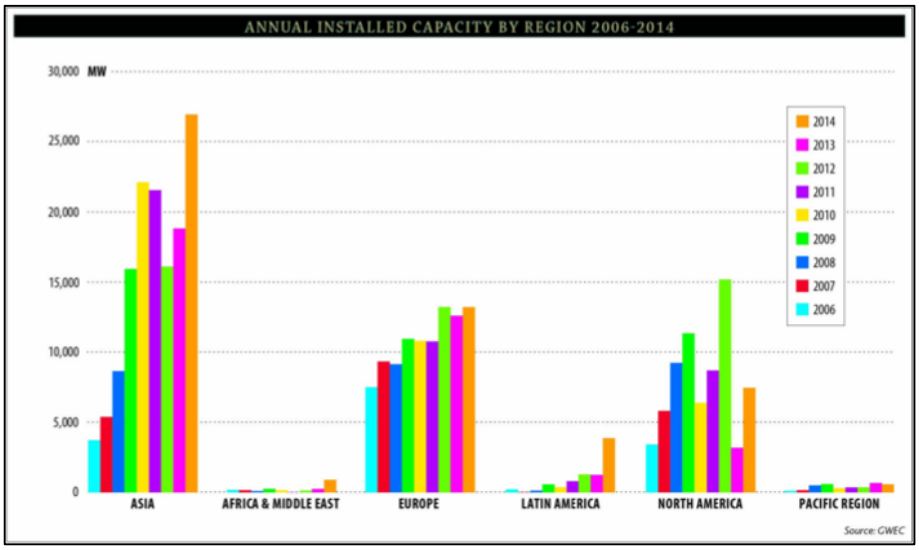


**Figure C7.3.** Annual Installed capacity of wind energy, by Region 2006–2014[290]

## C7.7 Mining

*Background*

The mining industry is of substantial economic importance in Southern Africa. Globally, ~50% of platinum and diamonds, ~40% of gold and ~20% of cobalt are sourced from this region. These minerals contribute greatly to the GDP and job creation in African countries[291]. Extreme weather events can have adverse effects on the mining production process. For example, high temperatures can result in the expansion of metals and affect the use of machinery, as well as reduced staff productivity. In addition, heavy rains result in temporary flooding that results mine closures and reduced road access. Open cast mine walls are particularly vulnerable to heavy rains as they are easily weakened by water and – coupled with seismic activity – this water can potentially trigger a mine collapse. Moreover, these extreme weather events have an adverse impact on mines' revenue generation. For example, in Australia, the 2010/2011 floods in Queensland restricted the production of 80% of mines, resulting in a production loss of AU$2 million[292]. To prevent loss and damage, it is therefore important that mine operators are forewarned of unusual weather patterns – such as intense rainfall – to take the necessary precautions timeously.

*Regulatory framework*

To prevent disruptions in the production process and ensure the safety of staff during extreme weather events, a regulatory framework for the mining sector is essential. Therefore, a regional regulatory framework was established in Africa in 2000 and in 2008, the Economic Community of West African States (ECOWAS) was established to implement mining legislation. This involved the

[290] Global Wind Energy Council, 2015
[291] http://www.sadc.int/themes/economic-development/industry/mining/. Accessed 13 August 2015.
[292] Mason, L., Unger, C., Lederwasch, A., Razian, H., Wynne, L. and Giurco, D., 2013. Adapting to climate risks and extreme weather: a guide for mining and minerals industry professionals. National Climate Change Adaptation Research Facility, Gold Coast.

development of three regional legal frameworks[293] which aim to: i) lead to the unification of the mining regimes and legislations across its member states; and ii) create a more stable and transparent legal environment in West African mining sectors. In addition, in 2003, the West African Economic and Monetary Union (WAEMU) adopted a mining policy and a mining code to coordinate legislation. While these regional initiatives are positive steps forward for the mining industry, the integration of these in the infrastructure have yet to be undertaken.

*Regional and national frameworks*

In the last decade, mining operations have expanded within both East and West Africa[294]. Consequently, several national frameworks had to been developed to guide the operation of mines and ensure the safety of its workers during extreme weather conditions.

*What are the climate and weather information needs of the mining industry?*

Mine managers require accurate and timely site-specific weather data for a number of reasons. For example, weather data can be used to inform decisions that have an impact on mine production and the well-being of workers and neighbouring communities. Weather information required by the mining industry include:

- data on rainfall and soil moisture to inform risk management strategies associated with *inter alia* flooding on mine sites, road access, slope stability and the siting and construction of mine infrastructure and worker facilities;
- temperature, UV radiation, radiant heat and relative humidity data as these have a direct effect on the establishment of a safe working environment; and
- wind direction and wind speed data as this enables the movement and dispersion of dust and hazardous gases to be monitored and for the development of strategies to suppress dust[295].

To establish a weather station at a mining site, there are several criteria which need to be adhered to[296]. These criteria include:

- capacity to withstand the disturbance resulting from drilling and the excavation of soil;
- an on-site service to replace and maintain the weather station on site;
- backup support to ensure all data recorded is registered on site and transferred to a central database;
- capacity to transport products across unpaved roads over large distances;
- the meeting of standards for horizontal wind monitoring; and
- adherence to licence and quality requirements.

*What are the climate products used by the mining sector?*

The following climate products and services are offered to the mining industry[297,298]:

- **Rain gauges accompanied by telemetry and SMS alarms** inform mine managers when extreme weather will affect the accessibility of sites are or mining operations.
- **Automation** pumps and valves in open cut mines are triggered by flooding and can be activated by weather sensors when pre-set rainfall volumes are reached within a particular time frame.
- **Weather Matrix** gives a simple graphical summary of weather risks day-by-day for up to one week in advance.

[293] These are frameworks are: i) the adoption of a Directive on the Harmonization of Guiding Principles and Policies in the Mining Sector in 2009; ii) the setting up of a Mineral Development Policy in 2011, to address issues such as optimising the value chain through the processing and value addition to minerals for maximum benefit; and iii) the Common Mining Code.
[294] KPMG. 2012. Mining in Africa towards 2020.
[295] For example, the frequency with which mine access roads and pit areas are watered.
[296] http://www.environdata.com.au/weather-stations-by-industry/mining. Accessed on 20 August 2015.
[297] http://www.MetraWeatherweather.com/Industry/Mining. Accessed on 20 August 2015.
[298] http://www.environdata.com.au/weather-stations-by-industry/mining. Accessed on 20 August 2015.

- **Mine-specific forecasts** are site-specific rain, wind and other weather forecast data – including hindcasting services and tailored solutions for all stages of a mining project.
- **Meteorologist briefings** enables a mine manager to contact an operational meteorologist to receive forecasts and validate weather information.
- **ePD probabilistic wind forecasts** present the percentage risk of high winds based on on-site observations.
- **StrikeCast** provide cloud-to-ground lightning strike observations and storm tracks with visual proximity alerts to mobile phones. This ensures operational and planning teams are kept updated on the potential threat, effect and timing of lightning storms in the area
- **Downtime forecasts** show the number of hours per day that weather could negatively impact mining operations.
- **Automatically generated weather alerts** are sent to the mobile phone of a user when observed or forecasted conditions exceed a certain threshold, such as the amount of millimetres of rain or wind speed.

## C7.8 Forestry

*Background*

The effects of climate change – including increased temperatures and shifting precipitation patterns – have an adverse effect on forests. Indirectly, these effects can result in long periods of drought, thereby increasing the risk of wildfires and disease outbreaks[299]. Such changes in climate affect species of trees and animals that have only responses to these changes. In addition, extreme weather events – such as intense rainfall and hurricanes – can severely damage plantations, equipment and infrastructure. Obtaining timely weather information can therefore help private forest owners improve their short- and long-term decision-making to prevent economic losses. However, there is a need for intermediaries to receive climate and weather information from NHMSs or other climate and weather providers and interpret it for forest landowners[300].

*What are the climate and weather information needs of the forestry sector?*

In 2013, a study undertaken in the United States determined the information required by foresters. The factors identified by foresters to be of importance – and therefore the factors that dictate their information needs – include: i) seasonal drought; ii) fire; iii) long-term shifts in weather patterns; and iv) storms.

*What are the climate products used by the forestry sector?*

The use of weather information by the forestry sector is still largely unexplored. Forest managers largely rely on weather information from the NHMS or forecasts from international private weather companies. For large plantations, there is usually investment in private automated weather stations as the planting and operations of a plantation can be affected by extreme weather events.

[299] Sturrock, R.N., S.J. Frankel, A.V. Brown, P.E. Hennon, J.T. Kliejunas, K.J. Lewis, J.J. Worrall, And A.J. Woods. 2011. Climate change and forest diseases. In: Plant Pathology 60:133–149.
[300] Carlton, J.S. et al. 2014. State service foresters' attitudes toward using climate and weather information when advising forest landowners. Journal of Forestry. 112: 9–14.

Disaster Risk Reduction

*Background*

Over the past two decades, natural disasters have become more frequent, affecting ~4.5 billion people – the majority of whom are the poor and marginalised[301]. As a result of climate change, these natural disasters are predicted to become more frequent and more extreme. It is therefore important that the poor and marginalised people in African countries prepare themselves against these disasters to reduce economic losses and the risk of losing lives.

*Regulatory framework*

It is recognised that a single law or entity alone cannot safeguard people against disasters, as disasters affect multiple sectors simultaneously. Disaster risk reduction therefore requires an integrated approach and a legal framework with clear rules and well-defined mandates. Until 2015, the Hyogo Framework of Action (HFA) served as a legal framework to assist countries with building resilience against disasters. Since 2015, the guiding framework has been the Sendai Framework for Disaster Risk Reduction (2015–2030). This framework outlines seven targets and four priorities for action to prevent new disaster risks and reduce existing ones. These include: i) understanding disaster risk; ii) strengthening disaster risk governance to manage disaster risk; iii) investing in disaster reduction for resilience and; iv) enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction[302].

In addition to the HFA and the Sendai Framework, the International Federation of Red Cross and Red Crescent Societies (IFRC) and the United Nations Development Programme (UNDP) developed a checklist on Law and Disaster Risk Reduction. The checklist serves as an assessment tool for lawmakers, implementing officials and other government authorities to review national and local level laws and regulations to enhance DRR. Furthermore, the list provides guidance on how to bring national legal frameworks in line with existing international standards and the Post-2015 Framework for Disaster Risk Reduction in particular[303].

*Regional and national frameworks*

In mid-2015, in response to the Sendai framework, the members of the SADC – including Malawi and Zambia – agreed in to develop a detailed plan of action that outlines how their countries can integrate disaster risk reduction across all sectors and throughout all levels of government[304].

## C7.9 Tourism

*Background*

Tourism is a rapidly growing industry and relies intrinsically on overall climate conditions to attract visitors. Moreover, climate and weather conditions have a strong influence on the operation of tourism businesses. Particularly, tourists coming from temperate regions prefer favourable weather conditions, such as limited rainfall, absence of strong winds and comfortable temperatures. In the short-term, tourists and tourism businesses are likely to be affected by weather conditions, such as rainfall, storms and changing temperatures. Receiving accurate and timely weather forecasts will therefore assist tourists and tourism businesses to anticipate and adapt to the changes in weather.

[301] IFRC & UNDP. 2014. Effective law and regulation for disaster risk reduction: a multi country report.
[302] IFRC & UNDP. 2014. Effective law and regulation for disaster risk reduction: a multi country report.
[303] IFRC. 2015. The checklist on law and disaster risk reduction.
[304] http://www.unisdr.org/archive/45663. Accessed 12 November 2015.

In the long term, the predicted effects of climatic change in an area – including increasing temperatures, sea-level rise and increasing frequency and intensity of storms – might have an impact on tourism operations and tourist visits. Another aspect of the tourism sector that is sensitive to climate change is the length and quality of the tourism season. Changes in these factors would have considerable implications for the long-term viability of tourism enterprises, as well as the competitiveness between tourism destinations. For example, wildlife tourism in Africa reflects current climatic conditions and distributions of species. Changing climate conditions – such as in precipitation, evaporation and flowering time – could potentially result in a shift in distributions and migration patterns of plant and animal species.

In addition to affecting preferences for tourist destinations, weather conditions can also be linked to tourists' safety. Although temperatures from 25–30°C and long daylight hours are an attraction to tourists, heat waves reduce the comfort of tourists, as the risk of heat stroke, dehydration and other heat-related illnesses increases. Natural disasters – such as hurricanes – also impact tourism as these events damage infrastructure and tourist attractions. Moreover, changes in quality and availability of water can increase the health risks for tourists. For example, reduced precipitation and increased evaporation can lead to local restrictions on use of water for irrigation or filling swimming pools[305]. Forested areas may be inaccessible to tourists because of an increased risk of fires and the limited quality of water in lakes and streams as a result of algal blooms.

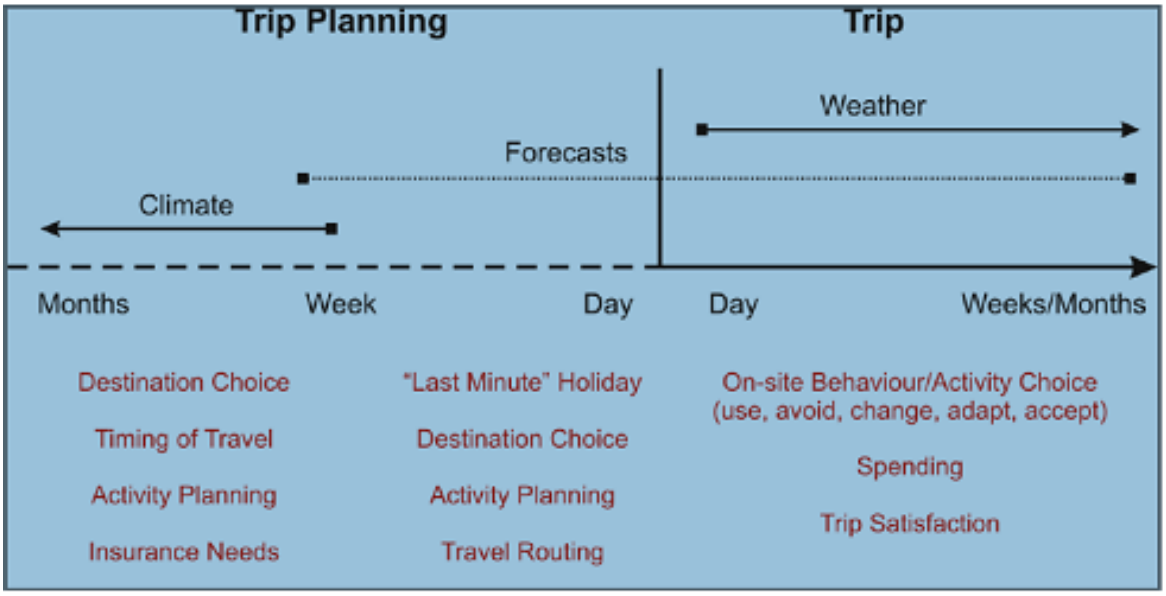


**Figure 7.4.** Climate and weather information for tourist decision-making (Scott & Lemieux, 2009).

*Regulatory framework*

The Tourist Climate Index (TCI) is a useful index not only because it combines climatic variables based on biometeorological studies into a single index that is readily interpretable by the traveling public, but also because it is designed to measure suitability of the climate resource for the most popular tourism activities in cities, i.e. sightseeing and shopping. An additional strength of the TCI is its widespread applicability, as the climatological data required for the TCI are generally available for most locations.

[305] UNWTO, UNEP & WMO, 2008

*What are the climate and weather information needs of the tourism sector?*

To anticipate the number of tourists visiting an area and improve their experience, the following climate information needs have been identified as important for the tourism sector: i) the number of daylight hours; ii) wind speed; iii) precipitation; and iv) air quality in urban areas.

*What are the climate products used by the tourism sector?*

Climate and weather information is available through many types of providers and media, for example, travel agents, tourism-marketing organisations, guide-books, the Internet, Television, radio, newspapers and mobile devices.

## C7.10 Transport

*Background*

The transport sector relies on the use of roads and railways throughout the year. The reliability of this infrastructure can be affected by adverse weather, which can damage structures and threaten human lives. Roads and railways can be engineered to limit damage from extreme weather events, for example high bridges can be constructed to avoid flooding[306]. However, this infrastructure development requires a considerable financial investment, which is often not available in developing countries. Consequently, accurate and timely information on climate and weather is important in these countries to: i) minimise damage to transport infrastructure; and ii) protect human lives from hazardous weather. In addition, in most countries in Africa, transport of goods is largely undertaken via road networks. Potentially hazardous weather conditions that can affect these roads are strong winds, heavy rainfall and intense heat.

In addition to terrestrial transport, marine transport, shipping and port development operations require specific meteorological services. To provide this, a comprehensive observation network of weather stations is required both on and offshore. In addition, NHMSs require adequate facilities to process these observations.

*Regulatory framework*

The Programme for Infrastructure Development in Africa (PIDA) was established by the African Union Commission, in partnership with the United Nations Economic Commission for Africa, the African Development Bank and the NEPAD Planning and Coordinating Agency. PIDA's overarching goal is to promote socio-economic development and poverty reduction in Africa through improved access to integrated regional and continental infrastructure networks and services[307]. This goal will be supported by the development of a common framework for African stakeholders to build the infrastructure necessary for more integrated transport, energy, Information and Communication Technology (ICT) and transboundary water networks to boost trade, spark growth and create jobs.

*Regional and national frameworks*

The Southern Africa Regional Integration Strategy (SARIS) was developed to create an integrated and internationally competitive region to reduce poverty

[306] https://www.wmo.int/pages/themes/climate/applications_transportation.php. Accessed 16 October 2015.
[307] http://www.nepad.org/regionalintegrationandinfrastructure/news/1628/africa-launches-ambitious-programme-infrastructure-de. Accessed 16 October 2015.

*What are the climate and weather information needs of the transport sector?*

The following climate and weather information needs have been identified as being of primary importance to the transport sector:

- wind – speed as well as direction – can influence fuel consumption through creating increased resistance;
- frost, in combination with rain or humidity, increases the probability of icing on roads;
- precipitation and heavy rain can lead to aquaplaning; and
- Wave and swell height, as well as the direction of the current, affects water transport.

***C7.11 Barriers and perceptions***

During consultations with representatives from the private sector, several barriers to invest in NHMSs through PPPs were identified, namely:

- A limited enabling environment for PPPs.
- Government inefficiency, particularly as the meteorology department is under the jurisdiction of a particular ministry and therefore the development of a sustainable model for participation can be prohibited.
- Limited incentive for the private sector to sell their services as their income goes straight to central government
- The majority of NHMSs are too focused on owning the data and not making data available for free.
- The limited coordination between multiple training programmes and projects that NHMS staff are involved in, which creates confusion and prevents progress[308].
- Limited decentralisation – particularly in West Africa – which hampers the expansion of NHMS services.
- The designation of the NHMS as a public sector entity which does not operate within the same framework as businesses. This creates a language and mind-set barrier to engage with the private sector[309].
- NHMS do not have adequate equipment for meteorological observations.

[308] Personal conversation with Mr R. Stern, University of Reading on 23 September 2015.
[309] Personal conversation with Mr E. Mukhala, WMO and Mr R. Stern, University of Reading.

## ANNEXURE. BIBLIOGRAPHY

Alemu, R. 2012. Regulation of Competition in the Liberalised Telecommunications Sector in Sub- Saharan Africa: Uganda's Experience.

Allison. 2005. Effects of climate change on the sustainability of capture and enhancement fisheries important to the poor: analysis of the vulnerability and adaptability of fisher folk living in poverty. Fisheries Management Science Programme Department for International Development, DFID: 167p.

AMCOMET. 2012. Integrated African Strategy on Meteorology: Investing in climate services for development.

Araya NS. 2011. Weather insurance for farmers: experience from Ethiopia. IFAD

Badjeck, MC, et al. 2011. Envisioning 2050: Climate Change, Aquaculture and Fisheries in West Africa, Senegal 14-16th April 2010. Workshop Report No. 2011-09. Penang/Bremen: WorldFish/ZMT.

Balzer, N & Hess, U. year. Climate change and weather risk management: evidence from index-based insurance schemes in China and Ethiopia. Revolution: From Food Aid to Food Assistance – instruments 103–123.

Becken, S. 2010. The importance of climate and weather for tourism. Land Environment and People.

Carter, M., de Janvry, A., Sadoulet, E. and Sarris, A. 2014. Index-based weather insurance for developing countries: A review of evidence and a set of propositions for up-scaling.

Carlton, J.S. et al. 2014. State service foresters' attitudes toward using climate and weather information when advising forest landowners. Journal of Forestry. 112: 9–14.

Clements, J., et al. 2013. The value of climate services across economic and public sectors: a review of relevant literature. United States Agency for International Development.

Clements, R. et al. 2015. Stakeholder Analysis: options analysis for a regional climate change programme to deliver more effective climate services, early warning and disaster risk reduction. Practical Action Consulting and the UK Met Office for Evidence on Demand.

Coulibaly Y. J., G. Kundhlande, N. Amosi, Tall A., Kaur H., Hansen J., 2015. What climate services do farmers and pastoralists need in Tanzania? Baseline study for the GFCS Adaptation Program in Africa. CCAFS Working Paper no. 110. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

Craft, Erik. 1999. Private Weather Organisations and the Founding of the United States Weather Bureau. Journal of Economic History 59, no. 4: p1063- 1071.

Davies, S., Sheridan, S., Hjort, A. and Boyer, H. 2014. Gap analysis of national and regional fisheries and aquaculture priorities and initiatives in Western and Central Africa in respect to climate change and disasters. FAO Fisheries and Aquaculture Circular No. 1094. Rome, FAO. 107 pp.

Dick, W and Stoppa, A. 2011. Weather Index-based Insurance in Agricultural Development a Technical Guide. International Fund for Agricultural Development (IFAD).

Dinku, T and Sharoff, J. 2012. ENACTS Ethiopia: Partnerships for Improving climate data availability, accessibility, and utility.

Dinku, T. et al. 2013. Combined use of satellite estimates and rain gauge observations to generate high-quality historical rainfall time series over Ethiopia. In: International Journal of Meteorology. Volume 34 (7): p2489–2504.

Eads GC, M Kieferet al. 2000. Reducing weather related delays and cancellations at San Francisco International airport. CRA Report No. D01868-00.

East African Community. 2004. Five Year Meteorological Development Plan and Investment Strategy.

ESW. 2006. Weather Risk Management: An Ethiopian Pilot. The World Bank.

EUMETSAT. 2012. EUMETSAT and Africa. European Meteorological Services at the Service of Africa.

FAO. 2008. The state of food and Agriculture. The United Nations. Rome

FAO. 2010. FAO Regional Strategic Framework for Africa.

FAO and UNEP. 2014. Overview of regional fisheries bodies off the Atlantic coast of Africa.

Federal Democratic Republic of Ethiopia Environmental Protection Authority. 2004. The 3rd National Report on the Implementation of the UNCCD/NAP in Ethiopia. Addis Ababa

GSMA intelligence. 2015. Market size and market opportunity for agricultural value-added-services (Agri VAS).

Greatrex, H. Hansen, J. Garvin, S. Diro, R. Blakeley, S. Le Guen, M, Rao, K and Osgood, D. 2015. Scaling up index insurance for smallholder farmers: recent evidence and insights. Research Program on Climate Change, Agriculture and Food Security.

Hallegatte, S. 2012. A Cost Effective Solution to Reduce Disaster Losses in Developing Countries Hydro-Meteorological Services, Early Warning, and Evacuation. Policy Research Working Paper 6058. The World Bank.

Hoedjes, JCB. 2015. Weather-and climate information cost/benefit and marketing analysis: Uganda.

Human Development Report: Malawi. 2014. United Nations Development Programme

ICAO. 2013. State of Global Aviation Safety.

IFAD. 2015. Remote sensing for index insurance. Findings and lessons so far.

International Federation of Red Cross and Red Crescent Societies & UNDP. 2014. Effective law and regulation for disaster risk reduction: a multi country report.

International Federation of Red Cross and Red Crescent Societies. 2015. The checklist on law and disaster risk reduction.

Jansen-Vebeke, M. 2001. Urban tourism and tourism research. In: Wall, G (ed.). Contemporary perspectives on tourism. pp 129-142. Department of Geography Publication Series, Occasional Paper November 17, University of Waterloo, Waterloo, Ontario, Canada.

Koetse, M.J. and Rietveld, P. 2009. The impact of climate change on weather and transport: An overview of empirical findings. Transport research Part D 14 205–221.

KPMG. 2012. Mining in Africa towards 2020.

Kulesa G. 2002. Weather and Aviation: How Does Weather Affect the Safety and Operations of Airports and Aviation, and How Does FAA Work to Manage Weather-Related Effects? The Potential Impacts of Climate Change on Transportation Workshop, October 1-2, 2002, DOT Centre for Climate Change and Environmental Forecasting.

Leviakangas, P. 2009. Valuing meteorological information. In: Meteorological Applications 16: 315–323.

Lienhard, A. 2006. Public-Private Partnerships (PPPs) in Switzerland: Experiences, Risks and Potentials. International Review of Administrative Sciences 72 (4): p547–63.

Meherette, E. 2009. Innovations in insuring the poor: providing weather index and indemnity insurance in Ethiopia. 2020 Vision.

Mason, L., Unger, C., Lederwasch, A., Razian, H., Wynne, L. and Giurco, D., 2013. Adapting to climate risks and extreme weather: a guide for mining and minerals industry professionals. National Climate Change Adaptation Research Facility, Gold Coast.

Mohammed, E.Y. and Uraguchi, Z.B. 2013. Impacts of climate change on Fisheries: Implications for food security in Sub-Saharan Africa. In Global Food Security.

NEPAD-OECD. 2011. Draft Policy Framework for Investment in Agriculture.

NEPAD. 2013. Agriculture in Africa: transformation and outlook.

Nielsen T. A qualitative assessment of weather indexed crop insurance in Ethiopia.

Rogers, David P.; Tsirkunov, Vladimir V. 2013. Climate and weather Resilience: Effective Preparedness through National Meteorological and Hydrological Services. Washington, DC: World Bank

Rosema, A. et al. 2014. FESA Micro-insurance: Crop insurance reaching every farmer in Africa", Scientific Final Report of Millennium Agreements Project no. 38. Commissioned by the Netherlands Ministry of Foreign Affairs, Directorate Sustainable Economic Development (DDE).

Scott, D. & Lemieux, C..2009. Weather-and climate information for Tourism. White Paper, commissioned by the World Meteorological Organisation.

South African Development Commnity (SADC). 2012. Regional Infrastructure Development Master Plan. Meteorology Sector Plan.

Sturrock, R.N., S.J. Frankel, A.V. Brown, P.E. Hennon, J.T. Kliejunas, K.J. Lewis, Worrall, J.J. And A.J. Woods. 2011. Climate change and forest diseases. In: Plant Pathology 60:133–149.

Taddese, B. 2015. Evaluation of the existing rainfall index insurance in Ethiopia's Nyala Insurance Company (NISCO), Ethiopia. In: The challenges of index-based insurance for food security in developing countries, conference paper.

Tall A., H. Kaur, J. Hansen and M. Halperin. 2015. Tanzania Summary of Baseline Studies: Country Report for the GFCS Adaptation Program in Africa. CCAFS Working Paper no. 124. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

United Nations Development Programme. 2014. Human Development Report: Malawi.

Venalainen, A. 2001. Meteorological data for agricultural models, a general analysis of different data sources. Finnish Meteorological Institute.

WMO & AMCOMET. 2012. Integrated African Strategy on Meteorological Services.

World Bank. 2014. World Development Indicators.

WMO. 2015. Valuing Climate and weather: Economic Assessment of Meteorological and Hydrological Services. World Meteorological Organisation.

Zambia National Meteorological Policy. 2013.