Assessing Sustainability and Effectiveness of Climate Information Services in Africa

Final Report

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ACRONYMS

AMCOMET	African Ministerial Conference on Meteorology
AWS	Automatic Weather Station
CIS	Climate Information Services
CDMS	Climate Data Management Systems
GFCS	Global Framework for Climate Service World Meteorological Organization
NGO	Non-Governmental Organization
NMHS	National Meteorological and Hydrological Service
PPP	Public-Private Partnership
SSA	Sub-Saharan Africa
UNDP	United Nations Development Program
WMO	World Meteorological Organization

EXECUTIVE SUMMARY

Effective CIS delivery requires access to reliable climate and weather information. In most cases this involves the National Meteorological and Hydrological Services (NMHSs) who have a national mandate to observe, forecast, and issue warnings for pending weather, climate, and water threats. Yet most African NMHSs contend with limited human capital, a lack of financial resources, and obsolete technologies. Despite covering a fifth of the world's total land area, and having a population of over one billion, Africa has the least developed weather and climate observation network of all continents, and the network is deteriorating. As a result, many NMHSs in Sub-Saharan Africa (SSA) lack the capacity to provide even a basic level of services such as emergency warnings.

In response, the *Assessing Sustainability and Effectiveness of Climate Information Services in Africa* (Sustainable CIS) project was funded by the US Agency for International Development (USAID). It sought to answer the question "*What are sustainable and effective models for CIS?*". This was accomplished through a combination of field-based research, collaboration and partnership building with national and international providers of CIS and associated data and technologies, and desk review. The project focused on a subset of SSA countries, including Senegal, Ethiopia, Rwanda, Malawi, Mali, Cote d'Ivoire, and Niger. Carried out by a Winrock International-led consortium, project partners included the Global Framework for Climate Services (GFCS)[1], the International Research Institute for Climate and Society (IRI), the Climate System Analysis Group (CSAG) and the AGRHYMET Regional Center.

The research undertaken focused on developing metrics to assess the capacity of NMHSs, identifying gaps to increase their capacity and sustainability, and developing approaches to bridge these gaps. In addition, the Winrock-led consortium evaluated the market for CIS in SSA, private sector business models that operate in the market, and developed a financial planning tool for NMHSs.

The project concluded that CIS in SSA will only become sustainable if the entire climate and weather enterprise is supported. If part of the system is not functioning, generating and delivering CIS to end users who need it most will be compromised. Systems thinking is key for taking CIS forward in a way that best serves the public. Many components of the climate and weather enterprise in SSA need support to i) strengthen key links in the system and ii) increase collaboration and partnerships across the system.

NMHSs are one of these key links in the system. They require support to remove structural, financial, and technical barriers, as well as support to strengthen advocacy and leadership at high levels of government and respond to end-user needs. Increased collaboration and partnerships – particularly with the private sector – are common themes to help improve the climate and weather enterprise. The private sector can help at many stages of the CIS data flow, but questions often arise regarding the role of the private sector in CIS. The private sector should be able to play a role in providing tailored information to sectors that NMHS cannot reach and there should be scope for NMHSs and the private sector to collaborate on data collection and sharing.

The research and tools developed by the Sustainable CIS project will help contribute to a better understanding of how to prioritize and support CIS investments and policy reform.

[1] GFCS is a global partnership of the World Meteorological Organization (WMO) with the UN International Strategy for Disaster Reduction, the World Health Organization, the World Food Programme, the Food and Agriculture Organization of the UN, and others.

1. INTRODUCTION

Climate Change in Sub-Saharan Africa

Africa is one of the most vulnerable continents to climate variability and change.[2] Sub-Saharan Africa (SSA) will experience associated severe effects, and these are likely to be disproportionate to the role this region has in causing climate change. African countries contribute only a small share of global greenhouse gas emissions, yet SSA will experience more climate stress and extreme weather events than most other parts of the world. At the same time, the region has little capacity to adapt to climate change. Poor infrastructure, limited access to markets, high illiteracy rates, and widespread poverty will hinder efforts to mitigate the effects of climate change in Africa[3].

In SSA, the changing climate will have far-reaching effects that differ widely across countries and regions. The impacts could be especially devastating as the continent relies heavily on agriculture. Between 60 and 70 percent of people in SSA depend directly or indirectly on agriculture for food security and income. These rural families generally spend 50 percent of their household incomes on food, making them very vulnerable to increased food prices or decreased incomes from agriculture.[4] The IPCC predicts that heat and drought stress will decrease crop productivity in Africa, with strong adverse effects on regional, national, and household livelihoods and food security. Flooding and increased pest and disease damage will also negatively impact the continent's food system infrastructure.[5]

Agriculture in SSA is particularly vulnerable to changes in rainfall patterns because irrigation is rare – in some parts, 95 percent of agriculture is rain-fed.[6] Most rural families depend on rain-fed agriculture for their livelihoods, and rain-fed agriculture generates a significant portion of national GDPs. Even small changes in inter- or intra-annual rainfall can have devastating impacts on agricultural productivity and rain-fed agriculture is especially important to the extreme poor, who are disproportionally women[7].

In the coming decades, the situation will become direr as rapid population growth and climate change threaten food security throughout SSA. Failure to address and adapt to climate change, especially as it impacts rainfall patterns, could jeopardize decades of development investments and improvements in livelihoods in SSA.

Importance of Climate Information Services

Decision-makers across the spectrum, including individual farmers, agribusinesses, government officials, need access to accurate climate and weather information to improve food security, raise agricultural incomes, and ultimately build resilience across economies. Yet despite the clear benefits of public investment in CIS, those

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[2] IPCC, 2014: *Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[3] Niang, I., O.C. Ruppel, M.A. Abdrabo, A. Essel, C. Lennard, J. Padgham, and P. Urquhart, 2014: *Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[4] Pinstrup-Andersen, P., R. Pandya-Lorch, and M. W. Rosegrant. 1999. *World Food Prospects: Critical Issues for the Early Twenty-First Century*. International Food Policy Research Institute, Washington D.C.

[5] IPCC, 2014: (ibid)

[6] Alexandratos N and Bruinsma J. 2012. *World agriculture towards 2030/2050: the 2012 revision*. ESA Working Paper No. 12-03. Rome: FAO.

[7] Wani, S.P.; Sreedevi, T.K., Rockstrom, J; Ramakrishna, Y.S. 2009; *Rainfed Agriculture – Past Trends and Future Prospects*. http://publications.iwmi.org/pdf/H041990.pdf

in SSA have historically suffered from underfunding and a range of other socioeconomic barriers. Therefore, National Meteorological and Hydrological Services (NMHSs) in SSA whose mandate is to observe, forecast, and issue warnings for pending weather, climate, and water threats, lack the capacity and resources to provide even basic services such as emergency warnings.

Despite covering a fifth of the world's total land area, and having a population of over one billion, Africa has the least developed weather and climate observation network of all continents, and the network is deteriorating. Most African NMHSs contend with limited human capital, a lack of financial resources, and obsolete technologies. As governments in SSA do not yet have the resources to invest in operating and maintaining (much less upgrading) their meteorological and hydrological services, the region's network of weather observation and communication infrastructure has steadily degraded over time.

In 2013, the World Bank estimated that SSA would need $1.5 – $2 billion in funding to make high-priority modernizations to CIS systems. Operations and maintenance would require an additional $400-$500 million per year. Public investment in NMHSs is low for a wide variety of reasons. Governments may prioritize other investments or fail to fully account for the far-reaching economic impacts of under- investing in CIS. In some cases, governments struggle to mobilize international finance. Governments may allocate funding for weather and climate observations across many different agencies and agriculture, water, and disaster relief agencies often have higher standing than NMHSs, so they receive more of the funding.

This historic under-investment in CIS has created a vicious cycle among NMHSs in SSA. With insufficient funding, NMHSs fail to produce timely and accurate information. This poor performance discourages governments from investing in NMHSs, so products and services deteriorate further.[8] The private sector can help fill the investment gap, but if governments do not recognize the role the private sector can play, they may fail to support or enable market involvement and could even restrict this type of support.

USAID-Supported Sustainable Climate Information Services Project

The U.S. Agency for International Development (USAID) funded The Learning Agenda on Climate Services in Sub-Saharan Africa to better understand how to develop effective, sustainable, country-led CIS programs in SSA. Two programs were implemented under this initiative: (1) Assessing Sustainability and Effectiveness of Climate Information Services in Africa (Sustainable CIS); and (2) Climate Information Services Research Initiative (CISRI). This report serves as the final report for the Sustainable CIS project.

The overall objective of the Sustainable CIS project was to develop models and options for the sustainable delivery of CIS in SSA, and to consolidate and extend knowledge on existing CIS in SSA. Project outputs are geared toward identifying and improving existing CIS programs provided by the public and private sectors, as well as design and assess potentially new CIS not yet implemented, but relevant to develop within local contexts.

The three main components of the Sustainable CIS project were:

1) **Assess NMHS capacity to deliver CIS.** An approach to evaluate the capacities of NMHSs to deliver CIS over time was developed and tested in Senegal, Ethiopia, Rwanda, Malawi, Mali, Cote d'Ivoire, and Niger. In doing so, the baseline capacity was established in each, advice on how to bridge capacity gaps was provided, and new technologies and approaches to combine data sets to meet needs was suggested.
2) **Assess markets for CIS and options to improve the sustainability of CIS.** An assessment of the market for CIS in SSA was conducted, as well as business models for the private sector that participate

[8] Rogers, D. P., & Tsirkunov, V. V. (2013). *Weather and Climate Resilience: Effective Preparedness Through National Meteorological Services*. Washington, DC: World Bank.

in CIS. A financial planning tool for NMHSs was also developed to help improve financial sustainability, including through collaborating with the private sector.

3) **Partnership building and outreach.** This component involved sharing research findings and ensuring uptake of knowledge and lessons learned.

The project focused on a subset of SSA countries, including Senegal, Ethiopia, Rwanda, Malawi, Mali, Cote d'Ivoire, and Niger. The project was carried out by a Winrock International led consortia that consists of the Global Framework for Climate Services (GFCS)[9], the International Research Institute for Climate and Society (IRI), the Climate System Analysis Group (CSAG) and the AGRHYMET Regional Center.

[9] GFCS is a global partnership of the World Meteorological Organization (WMO) with the UN International Strategy for Disaster Reduction, the World Health Organization, the World Food Programme, the Food and Agriculture Organization of the UN, and others.

2. ASSESSING NMHS CAPACITY AND BRIDGING GAPS

Enhancing CIS in Africa will require considerable investment, and international and bilateral development donors have increased investments to build the capacities of NMHSs on the continent. An objective method to understand NMHSs specific capacity needs, advice on technology options and data solutions to fill capacity gaps, and with metrics to track improvements over time can help target investments in CIS and demonstrate improvements from these investments.

This chapter summarizes work undertaken to develop and test a new tool and approach to objectively assess NMHSs capacity and track improvements over time along with desk analysis on technology and data options to improve capacity.

New Tool to Assess NMHS Capacity

To objectively and independently assess NMHS strengths and specific capacity needs, the USAID Sustainable CIS project built and piloted a framework called the *National Meteorological Service Assessment Tool*[10]. It combines existing schemes developed by the World Meteorological Organization (WMO) and Global Framework for Climate Services (GFCS) to objectively evaluate capacity strengths, gaps, and track improvements over time. This tool can also can help with planning and help donors prioritize investments and track capacity improvements over time. It is comprised of:

1) A framework to understand capacity;

2) A set of metrics based on that framework that measures capacity;

3) A survey questionnaire designed to collect data needed for the metrics; and

4) A data collection and analysis protocol.

The WMO and GFCS schemes that informed the *National Meteorological Service Assessment Tool* are:

1) **The five pillars of the GFCS** which identify the essential functions of the NMHS: (1) Observations and Monitoring; (2) Research, Modeling and Prediction; (3) Climate Service Information System; (4) User Interface Platform; and, (5) Capacity Development.

2) **WMO's four categories of NMHSs** define the level of service delivery according to four categories: (1) Basic Climate Services; (2) Essential Climate Services; (3) Full Climate Services; and (4) Advanced Climate Services. The tool did not include the "Advanced" category which can be added as needed.

Through a combination of literature review and expert judgment, metrics that helped describe the extent to which a NMHS satisfies each criterion in the evaluation framework were identified. This system allows NMHSs to be objectively and systematically evaluated on the extent to which they deliver CIS, based on the WMO categories of service delivery for each of the GFCS pillars.

[10] Dinku T., et al. (2018), *National Meteorological Service Baseline Assessment Tool: Assessing Capacity to Provide Effective and Sustainable Climate Information Services*, USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

The approach and tools were found to be effective and useful to understand technical strengths and gaps in NMHSs, but information on finances was very difficult to obtain. As such, it may be beneficial to involve financial analysts in interviews and data collection. More work is also needed to refine the metrics and associated tools. The metrics and weighting should be refined through additional consultation with experts from WMO, NMHSs, Regional Climate Centers, and other stakeholders. This could be accompanied by a sensitivity analysis to examine changes in ranking and final scores that would result from alternative weighting decisions and different choices of cut-off points for meeting scores in each category.

Assessing Access, Use and Impact of Agricultural Climate Services

The National Meteorological Service Assessment Tool is designed to identify gaps and support efforts to improve NMHSs, but not the extent to which CIS are accessed and used. Evaluating the delivery of CIS is nevertheless very important. Methods to do so often rely on household survey data, focus groups, and interviews which provide a snapshot but fail to offer the direct evidence of the real influence NMHS efforts have. Instead, impact evaluations, which are designed to generate direct and indirect evidence of the ultimate effects of CIS delivery (or lack thereof), may be more effective.

To further embed the tool within WMO and GFCS, and ensure uptake and use, the WMO added review of the *National Meteorological Service Baseline Assessment Tool* to the WMO Commission on Climatology workplan. The WMO is also working to integrate the tool into existing mechanisms such as the WMO Strategic Planning Handbook and national frameworks.

NMHS Capacity Assessment Findings and Recommendations

The *National Meteorological Service Assessment Tool* was applied to assess the current capacity and capacity gaps in seven NMHSs in SSA (Senegal, Ethiopia, Rwanda, Malawi, Mali, Cote d'Ivoire, and Niger). Full results of the capacity assessment are available in the report *NMHS Capacity Development Assessment Report*[11] and summarized in Table 1 on the next page (NMHS Category 4 is not shown as none of the countries offered this level of service delivery). The study did not analyze how NMHSs can raise revenue or form partnerships to address these gaps. Another part of the Sustainable CIS project developed a financial planning tool to help NMHSs in this regard (see Chapter 3).

[11] Lennard C., Steynor A., Kloppers K., Tadross M., Dlamini L., Madajewicz M. and Dinku T., (2018) *NMHS Capacity Development Assessment Report*. USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

GFCS Pillar	NMHS Category	Senegal	Cote d'Ivoire	Niger	Mali	Rwanda	Ethiopia	Malawi
1 O&M	1							
	2							
	3							
2 R&P	1							
	2							
	3							
3 CIS	1							
	2							
	3							
4 UIP	1							
	2							
	3							
5 CDV	1							
	2							
	3							

Table 1: Capacity scores for seven NMHS for the three WMO Categories (1=Basic Climate Services; 2=Essential Climate Services; 3=Full Climate Services) under each the of five GFCS pillars (O&M= Observations and Monitoring; R&P=Research, Modeling and Prediction; CIS=Climate Service Information System; UIP= User Interface Platform; and, CDV= Capacity Development). Green and yellow colors indicate that the criteria required for the category have been satisfied or partially satisfied, while red signifies that the criteria have not been satisfied.

The evaluation of these NMHSs revealed common gaps, which allowed for project experts to generate a series of priority recommendations across all NMHSs. These include:

- **Expand observation station networks and train staff in data quality control to generate more data to aid climate services.** This should include establishing funding mechanisms to assist with operating and maintenance (O&M) costs of station networks and providing standard, accessible and freely available databases. The expansion of such networks should be based on required use of the data. For example: climate monitoring requires accurate information, whereas early warning systems necessitate receiving data in real time, with less emphasis on high accuracy. Combining remotely sensed data (e.g., from satellites, radar, lightning) and data from weather stations, buoys, planes and upper air monitoring, can help expand monitoring coverage with reduced O&M costs.

- **Produce and communicate quantitative medium range forecasts (3-10 days).** While challenging to produce without computational infrastructure and qualified personnel, available online data (e.g., the Global Forecast System (GFS)) can be either physically or statistically downscaled. In most cases, NMHS staff need training to make use of existing forecasts, combine different sources of data, and use existing software tools to produce and disseminate local products. Bandwidth is an additional noteworthy constraint in Africa (as is its cost) - the bandwidth needed to access forecasts is sometimes beyond the budget of many African NMHSs. Moreover, investments are needed in hardware and expertise to physically downscale global forecasts. Statistically downscaling forecasts is a computationally easier option in many cases but requires extensive skills training to enable staff to derive the fundamental equations that underpin any statistical downscaling.

- **Develop staff capacities for research, development of user-orientated products and communications.** Most NMHSs are understaffed in terms of technically qualified research and development personnel, as well as staff capable of engaging climate information users, understanding their needs, and translating those needs into research and development tasks. NMHSs should recruit and develop new and young staff to fill these positions as well as train existing staff who can supervise the research and development of new products. In some cases, this may mean restructuring groups within the NMHS to take advantage of existing expertise (e.g., in agrometeorology), but these research and development groups should be able to cover product development across a wide range of sectors and users.

The following common barriers and suggestions for implementing priority interventions were also identified:

- **Limited governmental finances and budgets allocated to NMHSs.** This places a burden on salaries and recruitment efforts, as well as operating and maintaining equipment and forecasting systems. Lobbying government ministries, including finance ministries, can help to elevate the importance assigned to NMHSs. Especially when put in the context of disasters and providing useful information to sectors like aviation, reaching out to ministries can help underline the value of CIS. In terms of recruitment, a formal strategy to develop services and associated staff can also help to understand what positions are needed.
- **Institutional mandates and cooperation, including data sharing**. To develop climate services, NMHSs are often required to work with other government departments, NGOs/CSOs and the private sector. This requires flexibility in attitudes to mandates and institutional cooperation, which is sometimes difficult within rigid government structures. Entering into memorandums of understanding/agreements with external organizations to share data and develop new products, as well as engage different users of climate information can help to establish formal roles and expectations.
- **Short-term project-based funding from external donors**. It can stretch the capacity of NMHSs to satisfy project requirements when several projects are ongoing at the same time. It can also result in uncoordinated development of technical and human capacities, which dissipate when project funding ends. Formally convening a strategic oversight group within NMHSs to coordinate donor funding, based on a strategic plan for the development of the NMHS can help to avoid these issues.

County specific analysis is summarized in Annex 1, with additional detail found in the report *NMHS Capacity Development Assessment Report.*[12]

Optimal Technologies to Fill Capacity Gaps

To help identify the optimal combinations of technologies to fill capacity gaps, the report *Approaches to Combine Technologies for Weather Observation, Storage and Analysis*[13] examines the different technologies and associated issues regarding meteorological observation, data management, and data analyses for CIS in SSA. Key types of meteorological observation, including ground weather stations, atmospheric profilers, lightning detectors, weather radar, and satellite observations were reviewed, and case studies presented that showcase initiatives and innovative technologies.

[12] Lennard C., Steynor A., Kloppers K., Tadross M., Dlamini L., Madajewicz M. and Dinku T., (2018) *NMHS Capacity Development Assessment Report.* USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

[13] Siebert, A. Dinku T. and Curtis A. (2018), *Approaches to Combine Technologies for Weather Observation, Storage and Analysis*. USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA.

The following overarching recommendations were drawn from the evaluation of these technologies:

- The costs of purchase and installation, as well as maintenance costs, should be considered when purchasing meteorological instruments. For instance, automatic weather stations have gained popularity over many parts of Africa yet the cost of maintenance and spare parts (which must be imported) have introduced considerable logistical and financial challenges.

- Projects purchasing observing equipment should ensure that observational data generated be made available for international exchange in accordance with applicable WMO Congress Resolutions and WMO Regulatory Material. Donors may consider technologies such as 3-D printing of automatic weather stations and recoverable rawinsonde technologies to expand observational networks at lower costs. However, it is critical local NMHS be involved in the installation of these systems and provide a balanced investment of the real cost of operating and maintaining the system (human resources and capacity).

- The relatively poor status of Climate Data Management Systems (CDMS), particularly in Africa, prevents many NMHSs from efficiently integrating Automatic Weather Station (AWS) data and rescued data, as well as exchanging data, which is also heavily impacted by restrictive national data policies. Investing in powerful CDMSs managed by highly-skilled personnel is important as it will support efficient weather and climate services delivery. Donors should fund open source CDMS and ensure continuation of existing functional CDMS rather than proposing new systems.

- When evaluating options for filling data gaps or lowering costs, NMHSs should consider combining observations from different sources. For instance, optimal combinations of station rainfall measurements with satellite rainfall estimates can reduce the number rain gauges needed. Furthermore, satellite data may be useful where there are gaps in historical data.

- Governments should consider public-private partnerships and multilateral donor-supported arrangements to enhance and support the capacity and sustainability of individual NMHSs.

- NMHSs may need to review data sharing policies in the context of a broader discussion on the benefits of climate services for national development. NMHSs may contribute more to the national economy if climate data serve the public good rather than seeking to sell basic climate and weather data. Accordingly, governments should support their NMHSs to reduce dependence on revenue from selling data. Revenue should only be derived from providing specialized data analysis and services.

- Several tools and technologies could be useful to bridge gaps in data collection, analyses, storage, and dissemination. Emphasis should be placed on vetting these and recommending those that meet WMO requirements and guidelines. Approved tools and methodologies can be brought through a centralized hub, such as WMO Climate Services Toolkit (CST) that facilitates access to guidance, data, software tools, and training. Subsequently, attention will also need to focus on developing user capacities as procedural and human resources-related gaps on the user end constitute the biggest stumbling block in efficient use of tools and technologies.

Combining Existing Data Sources to Fill Capacity Gaps

There is a clear need for investment in meteorological observations in Africa, and given the financial constraints, they must be cost-effective. Rather than purchasing new instruments to meet all data needs, data can be generated at a reduced cost by combining observations from different instruments and institutions, as well as integrate different datasets at global, regional and national levels. To explore this solution, the report *Approaches to Collect, Exchange, and Integrate National and Global Datasets* [14] describes approaches to collect, exchange, and integrate national global sets, as well as challenges to data sharing and communicating climate observations and forecasts.

The report made the following key findings and recommendations:

- NMHSs should strive to make optimum use of climate data from different sources such as combing surface observations and satellite products. In addition to helping to fill temporal and spatial gaps in conventional weather observations, this may also reduce costs of observations.
- NMHSs may need to review data sharing policies in the context of a broader discussion on the benefits of climate services for national development. NMHSs may contribute more to the national economy if climate data serve the public good rather than seeking to sell basic climate and weather data. Accordingly, governments need to support their NMHSs to reduce dependence on revenue from selling data. NMHSs may instead derive revenue providing specialized data analyses and climate and weather services.
- Regional Climate Centers (RCC) can play a critical role assisting with capacity building, research, and development, including database support and training for NMHSs. RCC can also provide data from global centers to NMHSs. For example, some global model data are freely available, but it can be challenging for NMHSs to directly access international data sources due to technology barriers. Online portals that provide tailored access to global datasets for regional and national scale use are a more cost-effective way to improve data sharing.
- Computing and financial costs for running Global Climate Models (GCMs), or even intermediate length seasonal predictive models, can be prohibitive. African NMHSs should therefore work in partnership with regional centers and international collaborators. While modeling and downscaling efforts should be promoted, and climate services capacity built within NMHSs, doing so should not come at the cost of data collection and maintenance and shorter-term weather forecasting.
- NMHSs need to collect, organize and make available climate data collected by other government departments and agencies, as well as private institutions.
- Critical historical data is currently at risk of being lost due to outdated technology and deteriorating data storage capacity. Donors should therefore continue supporting NMHSs to rescue these data, increase access to it, and maximize the benefits of new investments in observation systems.

[14] Faniriantsoa, R., Curtis A., Dinku, T. and Siebert, A. (2018), *Approaches to Collect, Exchange, and Integrate National and Global Datasets*. USAID-supported USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA.

Tools and reports to help asses NMHS capacity and bridge gaps

Dinku T., et al. (2018), National Meteorological Service Baseline Assessment Tool: Assessing Capacity to Provide Effective and Sustainable Climate Information Services, USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

Dinku T., et al. (2018), *Development of Metrics to Assess National Meteorological Services in Africa*, USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

Siebert, A. Dinku T. and Curtis A. (2018), *Approaches to Combine Technologies for Weather Observation, Storage and Analysis*. USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA.

Faniriantsoa, R., Curtis A., Dinku, T. and Siebert, A. (2018), *Approaches to Collect, Exchange, and Integrate National and Global Datasets*. USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA.

Lennard C., Steynor A., Kloppers K., Tadross M., Dlamini L., Madajewicz M. and Dinku T., (2018) *NMHS Capacity Development Assessment Report*. USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

All documents are available online at:

https://www.climatelinks.org/projects/learningagendaonclimateservices

3. COLLABORATING WITH THE PRIVATE SECTOR FOR SUSTAINABLE CIS

NMHSs are responsible for providing CIS in SSA. Understanding their strengths and capacity gaps, along with different technology options and data sources to fill those gaps (Chapter 2), is part of the picture to improve CIS. Yet NMHSs do not operate in isolation. They are part of the climate and weather enterprise - the group of public, private, academic, and development organizations that deliver CIS products and services to end users. The sustainability of the entire climate and weather enterprise system —not just the NMHS—is critical. As such, it is important to look across the climate and weather enterprise to understand the strengths and limitations of actors beyond NMHSs, along with opportunities for collaboration and partnerships to increase CIS.

Private sector involvement in the climate and weather enterprise is nascent in SSA, but there are opportunities to increase participation of the private sector along the CIS value chain. Private companies can help expand CIS by generating weather and climate data and delivering CIS to end-uses, either on their own or through collaboration with NMHSs. Such collaboration can benefit NMHSs and private companies by helping to reduce costs and create new income for both.

This chapter summarizes research on the CIS market in SSA, the types of private sector business models that operate in this market, and a new financial planning tool that works with the *National Meteorological Service Baseline Assessment Tool* to help NMHSs understand existing resource gaps, advocate for adequate public sector resources, and create a strategy to earn additional revenue from paying clients.

CIS Market and Private Sector Business Models

Global CIS Market

The global market for CIS is growing rapidly. CIS expenditures increased by more than 35 percent from 2011-15 to an estimated total of $56 billion. Data for SSA is limited, but research indicates that the market for CIS in SSA, including both public and private expenditures, is approximately $1.4 billion.[15] This is a small market compared to other regions, but it shows signs of growth.

Developed economies invest heavily in CIS as they can generate strong, positive returns on investment[16] in two ways. First, investing in CIS yields benefits that greatly outweigh the costs. In the United States, Europe, and Australia, the cost-to-benefit ratio of national meteorological services ranges from 1:3 to 1:10,[17] with higher returns in lower-income countries

CIS Market Facts

- Global CIS market estimated at $56 billion and SSA market $1.4 billion (2014-2015).
- SSA has the lowest overall spending and second lowest per-capita spending on CIS.
- Over 15 companies provide CIS in SSA along the CIS value chain.
- The most common business models are business to business, business to business to consumer, and business to government.
- Fewer businesses engage directly with customers, but seven companies provided CIS to over 2.3m end users in SSA.

[15] Georgeson, L., Maslin, M., and M. Poessinow. 2017. *Global disparity in the supply of commercial weather and climate information services*. Science Advances. 3(5):1-9. http://advances.sciencemag.org/content/3/5/e1602632.full. Accessed 26 September 2017.

[16] Qadir, U. (2017). *Toward Sustainable Climate Information Services in Sub-Saharan Africa: A literature review*. Developed as part of the USAID project Assessing Sustainability and Effectiveness of Climate Information Services in Africa (Sustainable CIS Project).

[17] Perrels, A., Frei, T., Espejo, F., Jamin, L., & Thomalla, A. (2013). *Socio-economic benefits of weather and climate services in Europe*. Advances in Science and Research, 10, 65–70. doi:10.5194/asr-10-65-2013

associated with disaster risk management. Second, freely available weather and climate information can stimulate a larger private market for CIS, where investments in CIS generate a return. As of 2018, the U.S. government spends about $1 billion per year to sustain the National Weather Service. This investment, combined with an open data policy, has helped create a $7 billion market for private-sector weather and climate information products.

CIS Market in Sub-Saharan Africa

NMHSs are the primary source of CIS in SSA, but much of the CIS infrastructure is in disrepair, partly because NMHSs lack sufficient funds to maintain systems. NMHSs lack reliable funding to build and modernize observation infrastructure, operate and maintain systems, build staff capacity, and purchase the information technology and communications services required for data transmission and analysis. To maintain sustainable services over time, SSA NMHSs need ongoing funds for operations and maintenance, including information and communications technologies and services. Donors and governments should include this funding alongside infrastructure investments.

Private-sector companies can help fill gaps in services and are already providing CIS in many countries of SSA. In this region, the private sector plays a much wider role than using public data to create products and services for end users. It engages in the climate and weather enterprise at many different points along the flow of CIS information, from observations to forecasts to delivery of products to end users (Figure 1). International and local companies are investing in automated weather stations and infrastructure, NMHS capacity building, and delivering CIS to more than 2.36 million end users, most of whom are smallholder farmers.

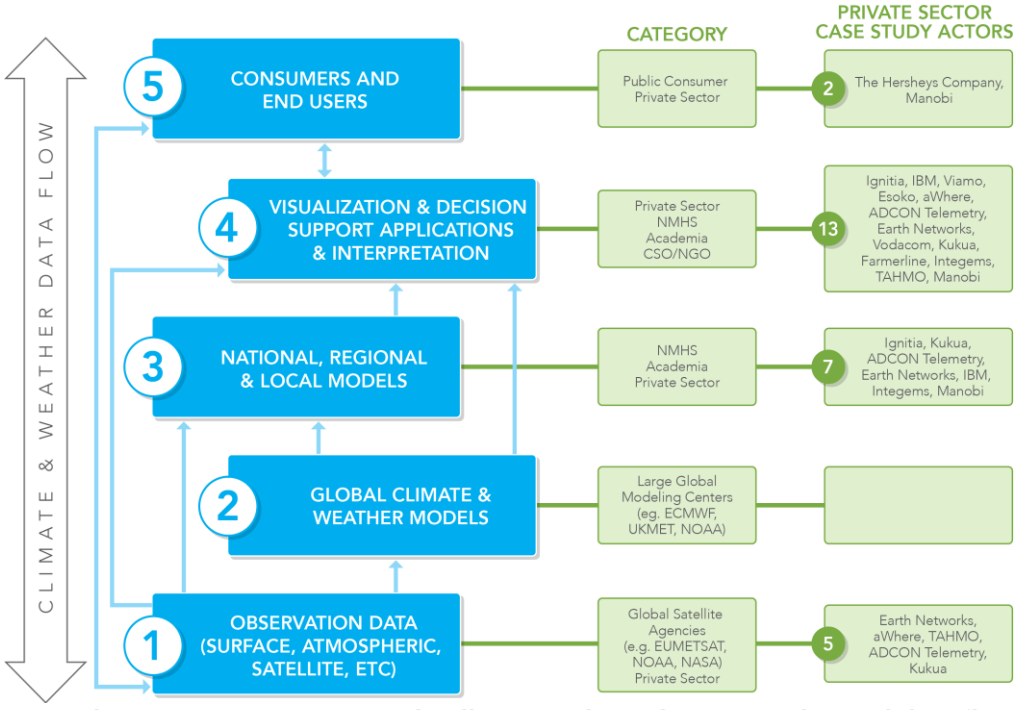

Figure 1 Private-sector engagement in climate and weather enterprise and data flow

At the first level (box 1, bottom of figure), systems collect weather and climate data on land or in the atmosphere, through in-situ or remote-sensing observation. Next, the information follows one of two paths. In the first path, data is fed into global, national, or local climate and weather models for use in model initialization and verification (boxes 2 and 3). In the second path, data passes directly to end-user visualization systems or the end users themselves (boxes 4 and 5).

Private sector companies use a wide variety of business models, and no single model is dominant. Businesses are the most active buyers of CIS, both for their own use and for that of the public. Eight different business models were identified from a total of 14 companies interviewed in a market analysis. The business-to-business-to-consumer model was the most common, while direct services to donors, governments, or consumers was least common. Some companies take gender into consideration in their decision-making or service offerings, especially with how data content is presented to the end user.

Donor support can help stimulate private sector participation in the CIS market, and some companies rely on these subsidies to develop and deploy products, services, and infrastructure. At the same time, however, subsidies distort the market. Some correlation was found between total amount of U.S. government donor funding into agriculture and the presence of private sector CIS companies. If donors' investments are not clearly indicated as time-limited, the private sector will not quickly explore further CIS business models or sources of funds in which to operate.

Two types of subsidies can be distinguished: (1) subsidies that support the development of infrastructure to collect and generate useable information; and (2) subsidies for the cost to the end user. Government and donors will probably always need to fund the basic infrastructure to collect and produce weather information as a public good, whereas subsidies that reduce the cost of CIS for the end user are more likely to distort the market.

Strong CIS markets are more likely to develop where governments share CIS data and allow private companies to sell services to end users. High-quality data gathered by governments can be used to build value-added products and services by the private sector. Policy that defines a process to develop partnerships rather than rigid roles of actors can promote partnerships, as can a neutral host to help mediate conflict and facilitate discussion between public and private actors. Partnerships in turn can grow the CIS market, increase the range of services available to end users, generate revenue for NMHSs, and support technology transfers to SSA. Private companies and other partners are successfully adapting CIS technology from more developed economies to fit local contexts in SSA. Companies that transfer technologies build local capacity in the process, both in the public and private sectors.

Challenges and Solutions to Public-Private Collaboration

A 2018 NMHS and private sector dialogue in Dakar, Senegal identified the following challenges to public - private collaboration:

- There is a public-private disconnect between data gaps, data priorities, technological needs and capacity to maintain new technology.
- NMHSs often lack strategic plans, business management expertise, negotiation skills and autonomy to equitably engage with the private sector.

Many of these obstacles could be addressed in strong NMHS strategic plans that:

- Support NMHS autonomy, outline NMHS and private sector roles, and opportunities for NMHS to collaborate on value added services that can generate revenue.
- Identify data gaps and priorities, technological needs and capacity to maintain new technology (the *NMHS Baseline Assessment Tool* can help), and
- Are informed by the NMHS Financial Planning Tool.

Other solutions include: drafting a private sector CIS code of conduct and creating a forum to regularly define mutual needs and goals and how to work together to achieve these.

Despite the benefits of public-private collaboration, SSA has only a small number of public-private partnerships. All 14 private-sector companies interviewed work with NMHSs, but the limited capacity of NMHSs poses challenges (see text box for additional challenges and solutions). NMHSs in SSA vary in organization and structure, from governmental departments to autonomous organizations. The operating model does not appear to influence the number of market participants or size of the market for CIS.

NMHS Financial Planning

Revenue generation from CIS is a rare but promising strategy for NMHSs and governments in SSA. Even where commercial clients purchase CIS from the government, the NMHS may not receive the revenue. Globally, nearly every industry invests in CIS, yet commercial aviation is the only sector in SSA to purchase CIS on a large scale to date. CIS could add value in many economic sectors, including agriculture, mining, and shipping/transportation. Few NMHSs in SSA have the information, expertise, and capacity to generate revenue by working with the private sector and as a result, NMHS budgets rely heavily on government and donor support.

To help NMHSs improve their financial planning and identify opportunities to reduce costs and increase revenue through partnering with the private sector, the *NMHS Financial Planning Tool* was developed. The tool helps users:

1) Understand existing resource gaps

2) Advocate for adequate public sector resources

3) Create a strategy to earn additional revenue from paying clients

The Excel-based *NMHS Financial Planning Tool* is available for download on the ClimateLinks website[18] and is accompanied by a *User Manual*. It was designed to be used by NMHS staff, World Meteorological Organization (WMO) personnel, government officials, donors, academia, NGOs, and other CIS stakeholders to guide investments and estimate possible revenues and cost savings. The Tool guides users to create separate budgets for the five pillars of a modern NMHS, as defined by the Global Framework for Climate Service (GFCS): (1) Observations and Monitoring; (2) Research, Modeling and Prediction; (3) Climate Service Information System; (4) User Interface Platform; and, (5) Capacity Development.

NMHSs can achieve greater financial sustainability by collaborating with the private sector to reduce costs and provide services to an expanded range of public and private customers**.** Thus, a key feature of the NMHS Financial Planning Tool is its ability to identify opportunities for public private partnerships or paying clients. Developed using case studies in Mali and Rwanda where companies were identified in several sectors that benefit from increased CIS provided by the NMHS, the Tool evaluates potential revenue sources across multiple sectors.

The assessment of CIS markets in SSA showed that donor and government support often fund infrastructure and equipment but does not adequately support the associated staffing and user interface costs. As such, the tool specifies expenses in two categories within each Pillar: (i) infrastructure and equipment, and (ii) core operations.

In most countries, NMHSs use several different financial planning tools: one for internal purposes, one for their work with the government, one for their work with donors, and one for any commercial services they provide. *The NMHS Financial Planning Tool* offers the following advantages:

- **Comprehensive**: Leads the user through a process of budgeting for all NMHS CIS services, includes revenue from all sources (government, donor, public and private paying clients), and covers all five GFCS Pillars.
- **Maps potential revenues from key economic sectors**: Helps the user identify potential CIS customers in key sectors (e.g. agriculture, transportation, construction, extractive industries) and estimate the value of services they could provide to specific customers in these sectors.

[18] See https://www.climatelinks.org/projects/learningagendaonclimateservices

- **Allows sensitivity analysis**: Allows the user to consider different budget scenarios for future years to determine the best strategy to ensure sustainable revenues over time.
- **Allows customization**: Users can choose which sectors to consider for paying clients, which services to offer paying clients, and how many years to project into the future.
- **Highlights cost-saving partnerships**: Guides users to consider partnering with private companies to save costs and/or generate revenues from new infrastructure/equipment.

The WMO is also working integrate the tool into existing mechanisms such as the WMO Strategic Planning Handbook and national frameworks.

Reports and tools on CIS markets, business models and NMHS financial planning

Usher J., Phiri C., Linacre N, O'Sullivan R, & Qadir U. (2018), *Climate Information Services Market Assessment and Business Model Review*, USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

Alquier, R., Venzac, P., Holthaus J., Phiri C., O'Sullivan R., (2018), *NMHS Financial Planning Tool*, USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

Alquier, R., Venzac, P., Holthaus, J., Phiri, C., and O'Sullivan, R. (2018), *NMHS Financial Planning Tool: User Manual*, USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

All documents are available online at:

https://www.climatelinks.org/projects/learningagendaonclimateservices

4. REFLECTIONS AND LOOKING FORWARD

Producing and delivering CIS involves multiple processes including interpretation, access, and application, with numerous factors affecting each. This system of interlinked actors collaborates – and sometimes competes – to generate and deliver CIS. End users need to be empowered to identify and define their needs and engage CIS providers through feedback mechanisms to ensure their needs are central to design and delivery.

CIS in SSA will only become sustainable if the entire climate and weather enterprise is supported. If part of the system is not functioning, generating and delivering CIS to those who need it most will be compromised. Systems thinking is therefore key for taking CIS forward in a way that best serves the public. Many components of the climate and weather enterprise in SSA need support to i) strengthen key links in the system and ii) increase collaboration and partnerships across the system.

NMHSs are one of the key links in the system as they are a priority source of reliable weather, water, and climate data. They require support to remove structural, financial, and technical barriers, as well as to strengthen advocacy and leadership at high levels of government and respond to end-user needs. The legal mandates of NMHSs vary from country to country, as do the risks, needs, and vulnerabilities of communities. NMHSs must advocate for themselves to influence state budgetary allocation by effectively communicating their value within governments.

The *National Meteorological Service Baseline Assessment Tool* will help objectively assess NMHSs strengths and areas where support is most needed. This can help focus investments which should be longer-term with financial flexibility to pivot and adapt interventions over time based on needs. Funds should allow for iterative follow-up and impact assessment and implementing partners should be empowered to report challenges openly. Donor-driven program strategies should also be aligned with national development plans and other donor institutions.

Increased collaboration and partnerships – particularly with the private sector – are a common theme to improve the sustainability of the climate and weather enterprise. The private sector can help at many stages of the CIS data flow, but questions often arise regarding the role of the private sector in CIS. Governments and NMHS must consider the efficacy of the climate and weather enterprise as a whole, including the role of climate information as a public good used for sustainable development, the public's right to access basic climate information, the scope for the private sector to generate data, and the scope for revenue sharing between NMHS and the private sector. Given many NMHS are not able to produce information adapted to the full range of sectors, there are opportunities for the private sector to play a role in providing tailored information to sectors that NMHS cannot reach. This could include bundling CIS with other services, such as agricultural, financial, and social services.

Similarly, there should be scope for NMHSs and the private sector to collaborate on data. The *NMHS Financial Planning Tool* is designed to facilitate this type of collaboration. Governments and donors should increase focus on policy interventions that support collaboration and partnership alongside technical and capacity building efforts. Further economic analyses are also needed to develop a more robust base of evidence of the value of CIS.

CIS are an important part of the development agenda and the Sustainable Development Goals. CIS that meet user needs and help informed decision-making will create multiple development benefits across sectors. For this to happen, CIS need to be strengthened and sustainable. This can only happen if the climate and weather enterprise is seen – and supported – as a system.

ANNEX 1: NMHS CAPACITY ASSESSMENTS

The following describes the specific capacity gaps in each country evaluated as well as recommendations for filling them in the SSA countries evaluated by the Sustainable CIS project.

Ethiopia

The Ethiopia NMHS performs well under the Climate Services Information System pillar and moderately well for the Capacity Development and Research and Prediction pillars. Capacity gaps exist under the Observation and Monitoring and User Interface Platform GFCS pillars.

To strengthen the climate services provision capacity, it is recommended that the NMHS prioritizes implementing its strategic plan to modestly expand surface and upper air stations, enhance the units satellite data reception, and processing system. The development of a staff training protocol/program should also be prioritized. Such a program could enhance staff capacity to engage users of climate information, ensure relevant information is produced, and that it is effectively communicated. Additionally, development of IT skills and bandwidth upgrades should be prioritized to ensure the NMHS is able to produce and communicate forecasts.

Cote d'Ivoire

Cote d'Ivoire's NMHS was found to have major capacity gaps across the board under each of the five pillars of the GFCS. However, the NMHS is making progress under the Research and Prediction pillar.

It is recommended that the NMHS prioritizes expanding surface and upper air stations. Additionally, training is imperative to ensure these stations are monitored by trained observers. Capacity development is needed for weather monitoring, weather and seasonal predictions and user engagement. The NMHS should engage relevant government structures and participate in policy development and planning related to the climate. The NMHS should also improve their internet presence to foster channels for communication.

Malawi

Malawi's NMHS performs well under the Climate Services Information System pillar and is making progress under the Research and Predictions and User Interface Platform pillars. Major capacity gaps exist under the Observation and Monitoring and Capacity Development GFCS pillars.

It is recommended that Malawi's NMHS prioritizes investing in expanded surface and upper air stations. Optimally, this should be accompanied a climate database management system and quality control practices. The NMHS should strengthen their research capacity by creating a clear research agenda and incentivizing further technical and academic training for staff. The seasonal prediction products of the NMHS should be enhanced. Additionally, the NMHS needs to improve and develop IT infrastructure and personnel, particularly in terms of providing uninterrupted power supply and enhanced bandwidth.

Mali

Mali's NMHS performs well under the Climate Services Information System and User Interface Platform pillar and moderately well for the Capacity Development. Capacity gaps exist under the Observation and Monitoring and Research and Prediction GFCS pillars.

It is recommended that the NMHS prioritizes expanding its surface station network with a significant increase in the number of Automatic Weather Stations (AWS). The NMHS should also prioritize developing and training meteorological technicians and forecasters. Additionally, upgrades to current IT infrastructure and personnel is suggested.

Niger

Niger's NMHS was found to have major capacity gaps across the board under each of five pillars of the GFCS. However, the NMHS is making progress under the Climate Services Information System pillar.

It is recommended that Niger's NMHS prioritizes expanding surface and upper air stations, with a specific focus on Automatic Weather Stations (AWS). A strategic 5-year plan that addresses human capacity development in terms of forecasting, climate services, user engagement, hardware and software development is suggested. Furthermore, priority should be given to training and developing senior forecasters and personnel skilled in user engagement.

Rwanda

Rwanda's NMHS performs well under the Climate Services Information System and User Interface Platform pillar. The NMHS performs moderately well for the Capacity Development, Research and Prediction, and Observation and Monitoring GFCS pillars.

To further strengthen this NHMS's climate services provision capacity, it is recommended that the NMHS prioritizes expanding upper air stations and more frequent data backup. The NMHS should also prioritize capacity development of forecasters and personnel skilled in user engagement, including training or recruiting a climate services specialist. The NMHS also requires an upgrade to the current IT infrastructure and personnel.

Senegal

Senegal's NMHS performs well under the Climate Services Information System pillar and moderately well for the Capacity Development and User Interface Platform pillars. Capacity gaps exist under the Observation and Monitoring and Research and Predictions GFCS pillars.

It is recommended that this NMHS prioritizes investing in and expanding observation stations. Additionally, it is suggested that the NMHS develop a strategic work program that identifies operational, research and managerial priorities as well as staffing portfolios/requirements to address these priorities. The NMHS, together with Senegalese and international research institutions, should engage in and incentivize research. In addition, seasonal prediction products of this NMHS should be enhanced.

ANNEX 2: MONITORING AND EVALUATION DATA

Sustainable CIS Performance Indicators

Performance Indicators	Life of Project Target	Actual FY17 (Oct 2016 – Sept 2017)	Actual FY18 (Oct 2017 – Sept 2018)	Actual FY19 (Oct - Dec 2018)	Actual LOP (Oct 2016 – Dec 2018)
Number of technologies or management practices under research, under field testing, or made available for transfer as a result of USG assistance (EG.3.2-7)	10	1	2	2	2
Under research	-	1	2	2	2
Under field testing	-	0	2	2	2
Made available for transfer	-	0	0	0	2
Number of scientific studies published or conference presentations given as a result of USG assistance for research projects (STIR-6)	14	3	15	0	18
Number of institutions with improved capacity to assess or address climate change risks supported by USG assistance (EG.11-2)	6	4	4	4	4
Number of new research collaborations established between USG-supported beneficiaries and other institutions (STIR-9)	3	0	1	2	3
Number of page views on project's pages on climatelinks.org website	TBD	655	4,433	839	5,927
Number of events in which CIS collaborates and shares its research, evidence, materials and/or learning products	14	0	12	8	20

Sustainable CIS reports and tools[19]

- Dinku T., et al. (2018*), National Meteorological Service Baseline Assessment Tool: Assessing Capacity to Provide Effective and Sustainable Climate Information Services*, USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

- Dinku T., et al. (2018), *Development of Metrics to Assess National Meteorological Services in Africa*, USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

- Siebert, A. Dinku T. and Curtis A. (2018), *Approaches to Combine Technologies for Weather Observation, Storage and Analysis*. USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

- Faniriantsoa, R., Curtis A., Dinku, T. and Siebert, A. (2018), *Approaches to Collect, Exchange, and Integrate National and Global Datasets*. USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

- Lennard C., Steynor A., Kloppers K., Tadross M., Dlamini L., Madajewicz M. and Dinku T., (2018) *NMHS Capacity Development Assessment Report*. USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

- Usher J., Phiri C., Linacre N, O'Sullivan R, & Qadir U. (2018), *Climate Information Services Market Assessment and Business Model Review*, USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

- Alquier, R., Venzac, P., Holthaus J., Phiri C., O'Sullivan R., (2018), *NMHS Financial Planning Tool*, USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

- Alquier, R., Venzac, P., Holthaus, J., Phiri, C., and O'Sullivan, R. (2018), *NMHS Financial Planning Tool: User Manual*, USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

- *Moving Climate Services Forward Workshop Report* (2018). USAID-supported Assessing Sustainability and Effectiveness of Climate Information Services in Africa project. Washington, DC, USA

- *Development of Metrics to Assess National Meteorological Services in Africa: Summary* (2018), background paper made available in English and French for the Sustainable CIS workshop *"Sustainable Climate Information Services (CIS): Expanding CIS delivery through innovative financial and business arrangements",* Dakar, Senegal, on 17-19 September 2018.

- *Policy Brief: NMHS Capacity Development* (2018), background paper made available in English and French for the Sustainable CIS workshop *"Sustainable Climate Information Services (CIS): Expanding CIS delivery through innovative financial and business arrangements",* Dakar, Senegal, on 17-19 September 2018

- CIS briefer series in collaboration with CISRI (forthcoming)

[19] https://www.climatelinks.org/projects/learningagendaonclimateservices

Sustainable CIS webinars

- Internal Learning Agenda webinar showcasing progress and learning in December 2017
- *African demand for weather and climate services, and business models for private sector engagement,* February 21, 2018[20]
- *Understanding Capacity Needs of African National Meteorological and Hydrological Agencies*, May 2nd 2018[21]
- Internal Learning Agenda webinar on Gender and Social Inclusion, May 9, 2018
- *Delivering African Climate Information Services Sustainably: Capacity gaps and recommendations for National Meteorological and Hydrological Services,* June 14, 2018.[22]
- *Demonstration and Application of a Financial Planning Tool for African National Meteorological and Hydrological Services,* July 31, 2018 (English) and August 2, 2018 (French).[23]

Sustainable CIS blogs[24]

- *Moving the Needle on Sustainable Climate Information Services in Sub-Saharan Africa: Learning from the Regional Outreach Workshop* by Olga Krylova.
- *Four Key Capacity Challenges to Provide Expanded Services on Climate Information Services* by Chris Lennard.
- *Strengthening Climate Information Services in Africa: Where are the Opportunities?* by Fatema Rajabali.
- *Examining Climate Information Services from Production to Uptake* by Learning Agenda on Climate Services in Sub-Saharan Africa, with a longer version of blog by Abby Love, Fatema Rajabali, and Robert O'Sullivan posted on Winrock and GFCS websites.[25]
- *A Systems Perspective to Climate Services* by Olga Krylova, Robert O'Sullivan, and Ali Blumenstock.
- *The Role of Public-Private Partnerships in Delivering Climate Information Services in Africa* by Fatema Rajabali, Robert O'Sullivan, and Jeremy Usher.
- *Climate Information Services to Empower Africa's Farmers* by Dr. Tufa Dinku.
- *New USAID Initiative to Evaluate the Sustainability and Effectiveness of Climate Services in Africa* by Robert O'Sullivan, Dr. Arame Tall, and Alioune Kaere.

[20] https://www.climatelinks.org/resources/african-demand-weather-and-climate-services-and-business-models-private-sector-engagement

[21] https://www.climatelinks.org/resources/understanding-capacity-needs-african-national-meteorological-and-hydrological-agencies

[22] https://www.climatelinks.org/resources/delivering-african-climate-information-services-sustainably-capacity-gaps-and

[23] https://www.climatelinks.org/events/demonstration-and-application-financial-planning-tool-african-national-meteorological-and

[24] https://www.climatelinks.org/projects/learningagendaonclimateservices

[25] https://www.winrock.org/examining-climate-information-services-from-production-to-uptake/ and https://www.wmo.int/gfcs/node/1201

Conferences, workshops and other knowledge management and dissemination

- CIS Learning Agenda team meeting (Sustainable CIS and CISRI projects), Sunday 26th February 2017, University of Cape Town, South Africa

- Sustainable CIS team meeting Monday 27th February 2017 University of Cape Town, South Africa

- IRI poster session on baseline metrics at the International Conference on Climate Services 5 in Cape town, South Africa on 28 February – 2 March 2017

- IRI presentation and discussions of the metrics approach at the WMO in Geneva on June 29-30, 2017

- 'Metrics for Assessing Baseline Capacities of National Meteorological and Hydrological Services in Africa' presented at the 2017 AMCOMET – Africa Hydromet Forum on 12-15 September 2017 in Addis Ababa, Ethiopia.

- Sustainable CIS and CISRI midterm review workshop, October 5th, 2017, Dakar, Senegal, Washington D.C. and virtual participation.

- *Climate Information on Resilient Development in Africa (CIRDA) project Regional Workshop: Towards Sustainability for Climate Information Services Achievements, Impacts, Lessons Learned and Next Steps, Lusaka, Zambia,* November 29 – December 1, 2017.

- AGRHYMET team presented the Sustainable CIS project's objectives and results at two regional events: PRESAGG (March 2018) and PRESASS (May 2018).

- West Africa Hydromet Forum with ECOWAS Sub-regional Platform, 19 – 21 September 2018 held in Abidjan, Côte d'Ivoire. Baseline metrics assessment of NMHS capacities approach was raised during the private sector engagement session.

- CIS Learning Agenda Conference "*What are we learning about climate information services delivery? Examining climate services from production to uptake"* held in Cape Town on 18th June 2018. Conference was led by the Sustainable CIS and CISRI projects. The Sustainable CIS project's work on baseline metrics, CIS market assessment, and financial planning work were all presented and discussed.

- Presentation on CIS market research at the *Adaptation Futures* conference in Cape Town in the session "Fostering Effective Investment and Private Sector Engagement in Climate Information Services in the Developing World", 20th June 2018.

- Sustainable CIS workshop *"Sustainable Climate Information Services (CIS): Expanding CIS delivery through innovative financial and business arrangements",* Dakar, Senegal, on 17-19 September 2018. The baseline metrics assessment and the financial planning tool were presented and discussed for participants feedback and recommendations for improving the tools.

- *Global Weather Enterprise* event on the margins of the *Commission on Instruments and Methods of Observations (CIMO)* on October 11-12, 2018 in Amsterdam, the Netherlands. Winrock presentation on CIS market analysis.

- Lunchtime Forum Seminar: *Way Forward for Climate Services Delivery: Systems Perspective* hosted by WMO on October 31, 2018 in Geneva, Switzerland. Presentation of key Sustainable CIS work to WMO staff and stakeholders (remote presentations).

- CIS Learning Agenda Conference *Moving Climate Services Forward: A Systems Perspective,* co-hosted by USAID and the WMO with support from the World Bank, 27th November 2018, Washington DC. Key findings and tools from the Sustainable CIS project and CISRI were presented and discussed along with key research and materials from USAID, WMO and the World Bank.