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AGRICULTURE GLOBAL PRACTICE TECHNICAL ASSISTANCE PAPER

CLIMATE INFORMATION SERVICES PROVIDERS IN KENYA

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Ministry of Foreign Affairs of the Netherlands

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Cover photos:

Left: "Neil Palmer, CIAT. A Kenyan farmer uses a mobile phone in the field."
Center: Woman walking. Photo: © Curt Carnemark/World Bank.
Right: Crops. Kenya. Photo: © Curt Carnemark/World Bank.

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FOREWORD

More than any other sector of the economy, agriculture relies directly on land and water resources that are essential elements of crop and livestock production. Agriculture takes up 40 percent of global land area and consumes 70 percent of global freshwater resources. Agriculture is also the sector most vulnerable to the effects of climate change. This is particularly true in Sub-Saharan Africa where agriculture is dominated by rain-fed production systems. Rapid and uncertain changes in rainfall and temperature threaten food production, increase the vulnerability of smallholder farmers, and can result in food price shocks and increased rural poverty. Yet Sub-Saharan farmers must do a great deal more than *maintain* current levels of production; they must *increase* production dramatically—enough to feed some 2.5 billion people by 2050. This will require a transformation of agricultural production on the continent.

Climate change is an additional lens through which prospects for agricultural development in Africa must be viewed in general, and agricultural risks in particular. Increased uncertainty about climate and weather seriously compound other risks affecting that sector in African countries, including poor soil fertility, limited resource endowments, and inadequate institutional capacity and technical capabilities that are needed to assimilate improved technologies. Farmers who have traditionally survived by mastering the ability to adapt to varying weather and climatic conditions are now increasingly faced with severely erratic weather patterns that overwhelm indigenous knowledge and traditional coping practices. Effective climate information and advisories will be instrumental in reducing the vulnerability of smallholders by enabling them to manage risk more effectively. Timely, cost-effective, and highly context-specific information such as weather forecasts and agronomic advisories will enable producers to improve decision making and optimize farm management practices to bolster climate resilience.

Efforts to provide climate information services (CIS) in Kenya have been supported by a number of international development agencies, nongovernmental organizations (NGOs), and private sector entities in recent years. These have been in addition to efforts by the Kenya Meteorological Department (KMD), which is nationally mandated to provide climate information and to archive climate data. In this document, the authors highlight the dynamic nature of CIS provision, technological developments using satellite remote-sensing techniques, and dissemination of information and advisories using information and communication technologies (ICT). Although technical progress in the generation and provision of CIS has been promising, its application and adoption still faces serious constraints. Among the most important of these constraints are scarce public resources and the lack of infrastructure and systems necessary to monitor and predict weather and climate. The authors also refer to various business models currently in operation, their limitations, and the importance of partnership in providing qualitatively better services through synergies from public and private resources.

Mobilizing and targeting resources to overcome these constraints has been an important reason the World Bank, Department for International Development (DFID), and the government of Kenya became determined to make CIS a vital component of our development work. It is our hope that this report moves that agenda forward, making increased productivity and resilience a reality for African farmers.

ACKNOWLEDGMENTS

This report results from contributions from a wide range of Climate Information Services Providers in Kenya. We thank everyone who contributed to its richness and multidisciplinary outlook. The overall guidance for the work was provided by Ademola Braimoh (World Bank), Noelle O'Brien (FICCF/DFID), and Peter Ambenje (KMD).

The report was written by Francis Ngari and Grace Obuya and edited by Xiaoyue Hou and Gunnar Larson. We are grateful for the substantive contribution of Joab Osumba (FICCF/DFID), Bill Leathes (UK Met), Shem Wandiga (ICCA), Boniface Akuku (KALRO), Mark Rüegg (CelsiusPro), John M. Ganthenya (JKUAT), Benjamin Njenga (Acre Africa), Elijah Mukhala (WMO), Diana Kishiki (KFS), and the Climate Information Services Providers that provided substantive feedback to the Climate Information Services Questionnaire. We also acknowledge the input of those that attended the FICCF/DFID–funded workshop to deliberate the findings of the field surveys.

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Finally, we acknowledge the financial support under the Bank Netherlands Partnership Program.

ACRONYMS AND ABBREVIATIONS

ACMAD	African Centre of Meteorological Applications for Development
ACRE	Agriculture and Climate Risk Enterprise Ltd.
AGRA	Alliance for a Green Revolution in Africa
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASDSP	Agricultural Sector Development Support Programme
AWOS	Airport Weather Observing Systems
AWSs	Automatic weather stations
CBOs	Community-based organizations
CCAFS	Climate Change, Agriculture and Food Security
CGIAR	Consortium of International Agricultural Research Centers
CHIESA	Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa
CIASA	Climate Information and Services Program for Africa
CIS	Climate information services
CSA	Climate-smart agriculture
DFID	Department for International Development
FAO	Food and Agriculture Organization (of the UN)
FEWSNET	Farming and Early Warning Network
FICCF	Finance Innovation for Climate Change Fund
GCAP	Global Climate Adaptation Partnership
GDP	Gross domestic product
GFCS	Global Framework for Climate Services
IBLI	Index-Based Livestock Insurance
ICCA	Institute of Climate Change and Adaptation (University of Nairobi)
ICPAC	Intergovernmental Authority on Development Climate Prediction and Applications Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and communications technologies
ILRI	International Livestock Research Institute
IVRS	Interactive voice response services
KARLO	Kenya Agricultural Research and Livestock Organization
KFWG	Kenya Forest Working Group
KMD	Kenya Meteorological Department
K Sh	Kenya shilling
MSG	Meteosat Second Generation
NAFIS	National Farmers Information Service
NDMA	National Drought Management Authority
NDOC	National Disaster Operation Centre
NGOs	Nongovernmental organizations
NOAA	National Oceanic and Atmospheric Administration
PACJA	Pan Africa Climate Justice Alliance
PSP	Participatory scenario planning
RCMRD	Regional Centre for Mapping of Resources for Development
SCF	Seasonal climate forecasts
SMS	Short message services
TAHMO	Trans-African Hydro-Meteorological Observatory
UNFCCC	United Nations Framework Convention on Climate Change
UON-ICAA	Institute for Climate Change and Adaptation
UoN-Met	Department of Meteorology, University of Nairobi
WMO	World Meteorological Organization
WRMA	Water Resource Management Authority

EXECUTIVE SUMMARY

Agriculture is a major driver of the Kenyan economy, contributing 54 percent to the national gross domestic product (GDP) and accounting for 65 percent of total export earnings. Kenya's GDP growth is highly correlated with the sector's performance, and its performance is highly volatile. The frequency and intensity of severe weather events has increased, and will be further exacerbated as a result of climate change. The country's overwhelming reliance on rain-fed agricultural production systems renders it highly vulnerable to food supply disruptions and shortages.

Climate information services (CIS) include immediate and short-term weather forecasts and advisories and longer-term information about new seeds and technologies and market developments. CIS is especially useful in helping farmers to manage risks in what is already an exceptionally risky sector in which to operate, and in offsetting much of the uncertainty that so often constrains decision making and innovation. CIS is a relatively new area in extension service delivery. Case studies reported on in this report reveal that only a small number of Kenyan farmers currently access CIS.

The World Bank, in partnership with the Finance Innovation for Climate Change Fund (FICCF) of the Department for International Development (DFID) and the Kenya Meteorological Department (KMD), collaborated in mapping the CIS providers in Kenya. The overall goal was to review the current capabilities for providing user-centered climate information and related services, and to make recommendations for improvement accordingly. The mapping exercise was carried out in five steps:

1. Review concepts and framework, and definitions of terminologies.
2. Conduct initial stakeholder analysis to develop a preliminary list of possible climate service providers and purveyors.
3. Administer questionnaires and interview service providers to obtain further data and validate information on the nature of CIS institutions, data processing techniques, service portfolios, information delivery mechanisms, and business approaches.
4. Host knowledge- and information-sharing workshop to further deliberate survey findings and share expertise and experience in CIS provision.
5. Prepare a report with recommendations for scaling up CIS services in Kenya.

CLIMATE INFORMATION SERVICES PRINCIPLES

Various challenges affect efforts to use climate-related information to improve the lives of smallholder farmers. Critical gaps in the design, delivery, and effective use of climate-related information for risk management among smallholder farmers can be filled by paying attention to five related principles:

» *Salience*—tailoring content, scale, format, and lead time to farm-level decision making.

» *Access*—providing timely access to remote rural communities with marginal infrastructure.

» *Legitimacy*—ensuring farmers own CIS, and shape their design and delivery.

» *Equity*—ensuring that women and poor and socially marginalized groups are served.

» *Integration*—providing climate information as part of a larger package of agricultural support and development assistance, enabling farmers to act on received information.

The notion of climate-related services connotes a kind of permanent relationship between observers, modelers, forecasters, disseminators, other intermediaries, and end users, primarily farmers. The knowledge and information that pass among the members of the relationship leave farmers in particular in a state of preparedness, of knowing what to do to adapt not only to seasonal variability in weather but also to longer-term trends in the climate itself. It can be useful to view the relationships between the parties who provide and apply climate information as a kind of value chain. For one thing, the providers and users are highly interdependent, and a weakness in any one link of the chain will have consequences with respect to the usefulness of the information, products, and services provided. For another, the concept of value addition applies to the process of gathering and interpreting information about weather and climate events and translating it into user-specific products that aid climate-resilient decision making. In the past, much investment in weather and climate services has been piecemeal, resulting in inefficiencies that undermine the systems' performance over time.

THE SURVEYS AND THEIR FINDINGS

Twenty-seven percent of the CIS providers covered in the study were private sector operators. Twenty-one percent were government agencies. Together, nongovernmental and community-based organizations (NGOs and CBOs) made up 21 percent of CIS providers. Seventeen percent of the providers surveyed were in research and academia, and another 14 percent were international organizations. The Kenya Meteorological Department (KMD) is the national meteorological agency mandated to collect and store climate data in the country, and to manage the climate information provision framework. KMD's role reflects the public good nature of benefits generated by CIS.

The CIS providers surveyed covered 11 different sectors. Eighty-three percent of them focused on agriculture and livestock. Approximately 80 percent of them offer early warning systems as their primary services—a proportion of which also serve agricultural purposes. Seventy-two percent offer agro-weather information services to support tactical and strategic decision making. Half of the CIS providers surveyed engage in weather forecasting. Some 41 percent of the CIS providers provide climate advisories for general government policies and decision-making and climate projections, whereas 28 percent of the providers service the insurance derivatives and transport safety advisory sectors.

The CIS providers use radar, satellite data, in situ automated weather observations, or some combination thereof. Most providers are in direct partnership with KMD in codeveloping climate information service/product or indirectly use data produced by KMD. Satellite data that are freely available were the preferred source by major consulting climate information service providers. Fifty-nine percent of them used in situ data from KMD.

Fifty-two percent of the providers surveyed disseminate climate information services through bulletins and newspapers. Forty-five percent use radio broadcasts, 34 percent use short message services (SMS), and 21 percent use websites. Ten percent use interactive voice response system (IVRS). These figures suggest that substantial opportunities remain to use modern information and communications technologies (ICT) in expanding market penetration.

Forty-one percent of the CIS providers use no communication feedback mechanism, suggesting significant absence of two-way information exchange between providers and users, and of participatory approaches in which users play a role in how services that affect them are designed. The primary feedback mechanisms employed by the CIS providers are SMS, meetings, and call centers—each of which were used by 21 percent of those surveyed. Fourteen percent of CIS providers rely on e-mails for feedback from users, and seven percent use interactive voice response services (IVRS) for this purpose. For climate information services specifically tailored for agriculture, postseason meetings with farmers and other users are very useful.

The diversity of services and service providers and delivery channels in the field of CIS in Kenya reflect a relatively well-developed industry, particularly in the area of agriculture. Barriers to more effective CIS provision and delivery include limited technical capacity and the absence of a framework to evaluate the quality of the CIS services provided. Most of the business models used by public, international, and for-profit and not-for-profit private CIS providers in Kenya are moreover financially too unsustainable to expand to the scale needed. Rapidly scaling up effective CIS in Kenya will entail prioritizing the following.

Improving technical and institutional capacity. The Kenya Meteorological Department will need to assess new, more sustainable business models, including ones involving public-private partnerships while devoting additional resources to staff training and professional development. Observation infrastructure will need to be modernized. Meteorological and hydrological networks will need to introduce more ground-based remote-sensing systems for "nowcasting" and very short-range weather forecasting to generate downscaled weather news. Capacity to generate downscaled weather forecasts will also be critical if local stakeholder participation in the generation of climate information is to be meaningful. The department's effectiveness can also be significantly strengthened with an improved legal and regulatory framework.

Improving coordination of CIS provision. Coordination between the different providers will benefit from a publicly available database of service portfolios. This will be useful for, among other things, structured learning and the dissemination of information about good practices. It is also likely to be instrumental in raising public awareness about the uses of climate information and spurring demand for it. Facilitation and brokerage (intermediation) of expertise will also be needed for complex projects. Approaches will need to be developed for protecting data ownership while eliminating barriers that prevent or discourage users from capitalizing on climate information more fully.

Establish a CIS quality management system. A quality management system geared toward appropriate definition of climate services, setting standards, labeling, and validation will be needed. A technical peer review panel is required to carry out demand-driven reviews of CIS activities, as needed and as relevant. This would help enhance project capacities and quality. Indicators for quality standards also need to be developed, and adherence to the standards enforced. Effective CIS delivery will also entail developing two-way interaction between the service providers and the service users to properly address users' needs and facilitate information that is specifically relevant to their decision making.

Foster codevelopment of CIS. There is greater need and demand for timely, relevant climate information codesigned with end users, based on properly downscaled weather forecasts at the subnational level. Given the knowledge-intensive nature of CIS provision, there is a need for actor-based platforms to facilitate knowledge acquisition. Promoting the adoption of effective CIS will require well-designed, inclusive, and innovative systems, with clear quality checks and balances. The priorities include strengthening farmers' knowledge of CIS benefits and to facilitate their use of CIS in decision making. This will result in more robust CIS systems and user-led approaches. Implementing colearning and comanagement strategies that involve providers and users is one way to do this. Transdisciplinary, multidisciplinary research to support codevelopment of weather and climate services is also needed to enhance CIS knowledge integration. CIS providers and users working closely together will, in turn, lead to mutual accountability.

Create sustainable public-private partnership. The limitations of the pure government- and pure market-based CIS provision models warrant testing new approaches to public-private partnerships. Public-private partnership helps to break the downward spiral of underinvestment, poor infrastructure, deficient services, low visibility, and insufficient funding that threaten national meteorological services. Public-private partnerships have the potential to provide more efficient services through synergies and complementarities from public and private strengths. Public-private partnerships may also lead to image enhancement for the current government monopoly model. Although KMD retains its central role in climate information management, giving priority to the provision of forecasts and warnings of severe weather, floods, and droughts, the private sector can contribute particular competencies in the form of innovative technology, design of resilient infrastructure, improved information systems, and the management of complex projects. Additionally, KMD may also consider a paradigm shift into state enterprise or alternative models. Yet a successful transition from fully governmental to an effective market-oriented service, on-demand agency requires a fundamental transformation in institutional culture and mechanisms for staffing and business practices. This can be a significant challenge, although the benefits it can bring about in terms of developing a culture of service delivery and user engagement are significant.

CHAPTER ONE
INTRODUCTION

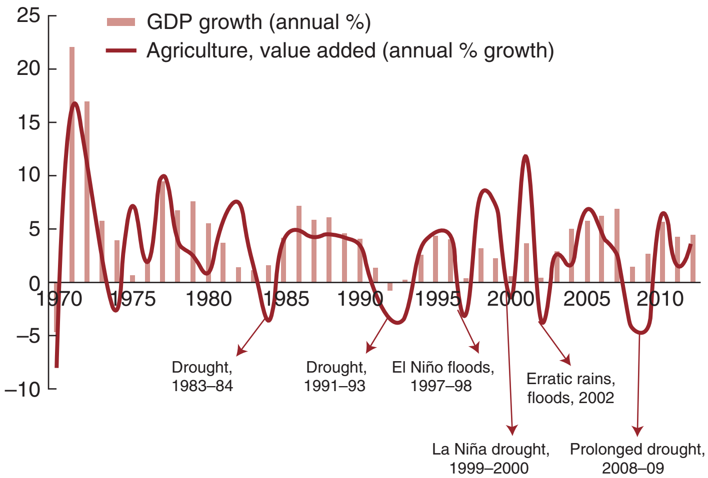
Agriculture is a major driver of the Kenyan economy, contributing 27 percent to the national GDP directly, a further 27 percent through manufacturing, distribution, and service sectors. It accounts for 65 percent of Kenya's total export earnings and generates roughly 60 percent of the country's foreign exchange earnings. The sector employs more than 75 percent of Kenya's workforce and generates most of the country's food requirements, playing a key role in poverty reduction. Smallholder farms account for 85 percent of employment and 75 percent of total agricultural output.

Kenya's GDP growth is highly correlated with the agricultural sector's performance, which is highly volatile (figure 1.1). Extreme weather events, largely droughts and to a lesser extent floods, have been the principal driver of agricultural volatility in Kenya. The frequency and intensity of severe weather events has increased, and will be further worsened in the future as temperatures increase with climate change. Recurring drought has profound effects on the agricultural sector, particularly in maize and livestock production systems. Frequent drought events result in precipitous crop losses, livestock deaths, spikes in food prices, increased food insecurity and malnutrition for the poor, and rural population displacement (World Bank, 2014).

Kenya's strong reliance on rain-fed agricultural production systems has rendered the country increasingly vulnerable to food supply disruptions and shortages. Amid declining yields, productivity gains have come largely through land expansion into marginal areas that receive lower and more variable rainfall. This has contributed to a growing structural deficit in food production. Extensive livestock systems and pastoralism in Kenya's northern rangelands are also particularly vulnerable to the effects of drought. Emergency food aid and other ex post responses have helped fuel growing dependency and declining resilience, particularly among the poorest and especially in arid and semi-arid lands.

Meeting the challenges of the agriculture sector will require both investments in building resilience to near-term shocks and in adapting to long-term climate change. In this context, providing farmers with timely and highly practical information will be crucial.

FIGURE 1.1. RELATIONSHIP BETWEEN KENYA'S GDP GROWTH, AGRICULTURAL VALUE ADDED GROWTH, AND EXTREME WEATHER EVENTS



Source: World Bank 2015.

Climate information services (CIS) include immediate and short-term weather forecasts and advisories as well as longer-term information about new seeds and technologies and market developments. CIS is especially useful in helping farmers to manage risks in what is already an exceptionally risky sector in which to operate, and in reducing uncertainty that so often constrains decision making. CIS is designed to inform farmers' decisions about what to grow, when to plant and harvest, how to allocate their labor, and where to sell their produce. Much of this information is specifically adapted for use in local conditions and quickly becomes recognized as being highly relevant to the needs of farmers operating in local contexts.

Building on the report *Increasing Agricultural Production and Resilience through Improved Agro-Meteorological Services*, the World Bank, in partnership with the Finance Innovation for Climate Change Fund (FICCF) of the Development for International Development (DFID) and the Kenya Meteorological Department (KMD), carried out a mapping of the CIS providers in Kenya. The objective was to review the current capabilities for providing user-centered climate information and related services, and to recommend improvements to contribute to universal access to useful and useable climate information services in Kenya. The mapping exercise sought to develop an understanding of the range of services currently available and the institutions providing them.

The assignment was carried out in five steps:

1. a review of concepts and framework, and definitions of terminologies to make the report understandable to a broad audience;
2. initial stakeholder analysis to develop a preliminary list of possible climate service providers and purveyors;
3. administering questionnaires and interviewing providers to obtain further data and validate information on the nature of CIS institutions, sectoral focus, data processing techniques, service portfolios, information delivery mechanisms, and business approaches;
4. knowledge- and information-sharing workshop to further deliberate survey findings and share expertise and experience in CIS provisions; and
5. preparation of the report and recommendations for scaling up CIS services in Kenya.

CHAPTER TWO
CONCEPTUAL FOUNDATION

DEFINITIONS OF CONCEPTS AND TERMINOLOGIES

Climate[1] is usually defined as the average weather condition, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands of years. The World Meteorological Organization (WMO) often defines a period of 30 years. The influence of temporal and spatial scales on the state of the atmosphere has implications for observability and predictability of weather and climate, and for the design of climate information services (CIS) (figure 2.1).

Weather is the atmospheric condition in a given place, including variables such as temperature, rainfall, wind, or humidity.

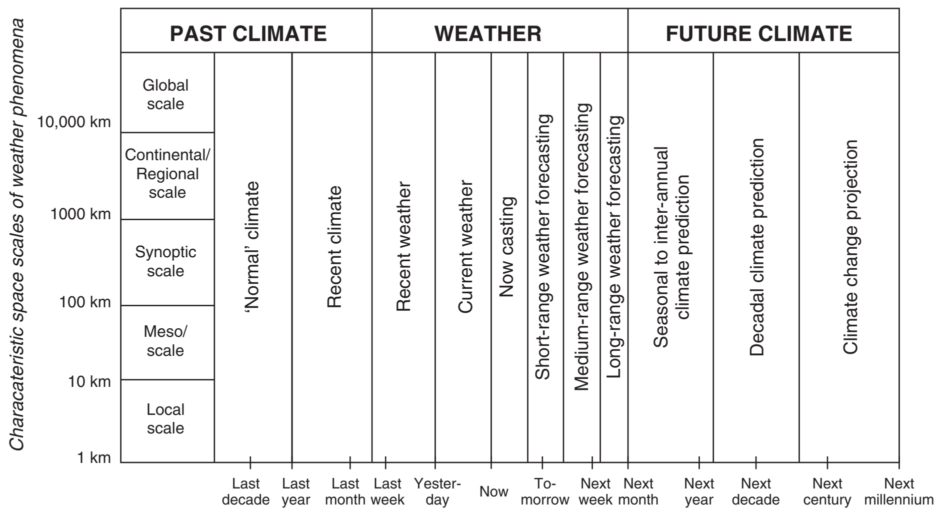
Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. However, the United Nations Framework Convention on Climate Change (UNFCCC) emphasizes the anthropogenic forcing and defines climate change as a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that occurs in addition to natural climate variability observed over comparable time periods.

Climate prediction or forecast is the result of an attempt to produce a most likely description or estimate of the actual evolution of the climate in the future, for example, at seasonal, inter-annual, or long-term time scales.

Climate projection is the response of the climate system to emission or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often

[1] Unless otherwise stated, all definitions are taken from *Intergovernmental Panel on Climate Change (IPCC) 2014*, http://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf.

FIGURE 2.1. SPATIAL AND TEMPORAL SCALES OF WEATHER AND CLIMATE



Approximate time-scale terminology for weather and climate description and prediction

based on simulations created by climate models. Climate projections are distinguished from climate predictions to emphasize that climate projections depend on the emission/concentration/radiative forcing scenario used, which are based on assumptions, concerning, for example, future socioeconomic and technological developments that may or may not be realized, and are therefore subject to substantial uncertainty.

Climate variability refers to variations in the mean state and other climate statistics (standard deviations, the occurrence of extremes, and so on) on all temporal and spatial scales beyond those of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or from variations in natural or anthropogenic external forces (external variability).

Extreme weather event denotes an event that is rare within its statistical reference distribution at a particular place. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called extreme weather may vary from place to place. An **extreme climate event** is an average of a number of weather events over a certain period of time, an average that is itself extreme (for example, rainfall over a season).

Uncertainty is an expression of the degree to which a value (for example, the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have a variety of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology or uncertain projections of human behavior. Uncertainty can therefore be represented by quantitative measures (for example, a range of values calculated by various models) or by qualitative statements (for example, reflecting the judgment of a team of experts).

Climate services involve providing climate information in a way that assists decision making by individuals and organizations (WMO 2014). A service requires appropriate engagement along with an effective access mechanism and must respond to user needs (WMO 2014). It is a user-driven development and provision of knowledge for understanding the climate, climate change and its impacts, and guidance in its use to researchers and decision makers in policy and business (JPI Climate 2011, 44). Climate information service principles are highlighted in box 2.1.

Climate product is a derived synthesis of climate data. A product combines climate data with climate knowledge to add value (WMO 2014).

Climate information can mean climate data, climate products, or climate knowledge (WMO 2014). Climate

BOX 2.1. CLIMATE INFORMATION SERVICES PRINCIPLES

Various challenges confront efforts to use climate-related information to improve the lives of smallholder farmers. Critical gaps in the design, delivery, and effective use of climate-related information for risk management among smallholder farmers can be filled by paying attention to five prerequisites (Tall et al. 2013):

Salience	Tailoring content, scale, format, and lead time to farm-level decision making.
Access	Providing timely access to remote rural communities with marginal infrastructure.
Legitimacy	Ensuring that farmers own climate services and they shape their design and delivery.
Equity	Ensuring that women, poor, and socially marginalized groups are served.
Integration	Providing climate information as part of a larger package of agricultural support and development assistance, enabling farmers to act on received information.

information is "the transformation of climate related data together with other relevant information and data into customized products such as projections, forecasts, information, trends, economic analyses, assessments (including technology assessments), counseling on best practices, development and evaluation of solutions, and other services in relation to climate or responding to climate change that are of use to society."[2]

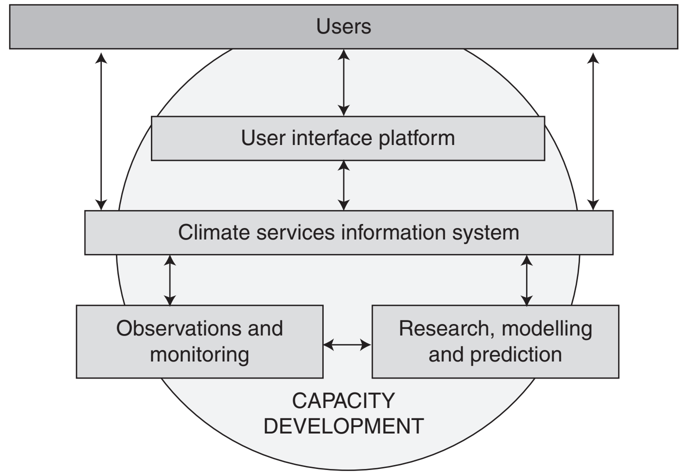
Climate data consist of historical and real-time climate observations along with direct model outputs covering historical and future periods. Information about how these observations and model outputs were generated ("metadata") should accompany all climate data (WMO 2014).

THE GLOBAL FRAMEWORK FOR CLIMATE SERVICES

At the World Climate Conference-3 in 2009, delegates of 155 nations endorsed a Global Framework for Climate

[2] UK Climate Service Providers series of workshops in November 2014.

FIGURE 2.2. THE GLOBAL FRAMEWORK FOR CLIMATE SERVICES



Source: WMO 2011.

Services (GFCS) "to strengthen the production, availability, delivery and application of science-based climate prediction and services." The GFCS implementation plan targets gaps in climate services in support of key climate-sensitive sectors, including food security, water, health, and disaster risk reduction in vulnerable developing countries.

The GFCS implementation plan contains five pillars essential to the design of CIS (figure 2.2). These include the following:

1. User Interface Platform that provides a means for users, climate researchers, and climate service providers to interact, thereby maximizing the usefulness of climate services and helping develop new and improved applications of climate information.
2. Climate Services Information System used to protect and distribute climate data and information according to the needs of users and according to the procedures agreed by governments and other data providers.
3. Observations and Monitoring component that ensures that the climate data necessary to meet the needs of climate services are generated.
4. Research, Modeling, and Prediction component that assesses and promotes the needs of climate services within research agendas.
5. Capacity Development component that supports systematic development of the necessary

institutions, infrastructure, and human resources to provide effective climate services.

The pillars are meant primarily as a conceptual model and in practice there is some overlapping of functions and responsibilities. The long-term, high-level outcomes and benefits include user communities that are able to make climate-smart decisions and climate information that is disseminated effectively and in a manner that lends itself more easily to practical action. Although many individual programs and projects have focused on particular elements of the framework, the challenge is that about 70 nations currently have no or inadequate climate service.[3] GFCS, however, aims to improve climate services over the next ten years to help countries and communities cope with natural variations in climate and with human-induced climate change. These integrated approaches are more easily addressed with longer-term programs that link well with other existing or planned initiatives. The UN-led GFCS—along with other initiatives—are now providing important guidance for new programs and fostering and promoting government recognition of the benefits of climate services and providing a structure for a more coordinated approach.

The integration of weather and climate information into decision making is recognized as a transdisciplinary, multidisciplinary process involving components that include climate science and information services, translational science (developing appropriate communication approaches and delivery channels), and issues of governance to incentivize service delivery and use. Considerable work has been carried out to improve capabilities in some aspects of these individual components, including pilot projects, generally of subnational scale, to improve interaction and mutual understanding between climate information providers and users.

There have been many initiatives to strengthen climate and weather information services across Africa in the past few years. It is commonly observed that availability and uptake of information and services still occur at a relatively low level and that this represents a lost opportunity for social and economic development. There is a growing consensus that a lack of a holistic approach and long-term support of the development of weather and climate services is a major contributing factor that limits progress in uptake (Graham et al. 2015). The development of climate-smart agriculture (CSA) and related programs in Kenya provides opportunities to address the low uptake and strengthen CIS in the agriculture and food security sector.

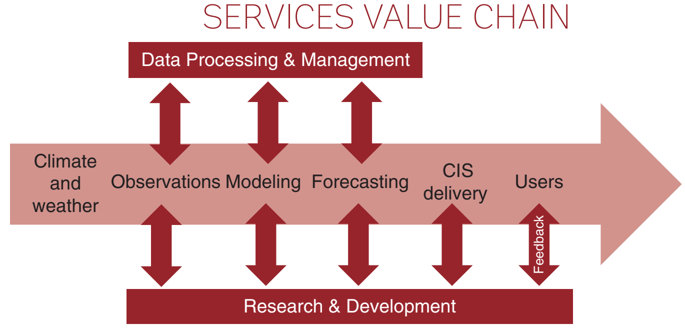
WEATHER AND CLIMATE SERVICES VALUE CHAIN

The notion of climate-related services connotes a kind of permanent relationship between observers, modelers, forecasters, disseminators, other intermediaries, and end users that leaves the users, farmers in particular, in a state of preparedness, of *knowing what to do* to adapt not only to seasonal variability in weather but also to longer-term trends in climate change itself. The value of the information is only realized at the end of the chain in which decisions are made based on the information provided (figures 2.3 and 2.4).

There are three main reasons climate and weather services must be viewed as a value chain:

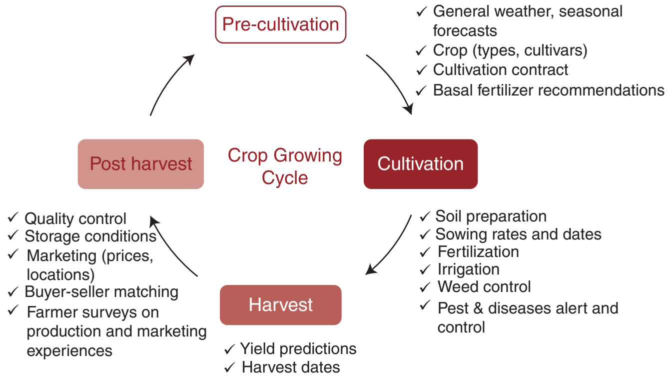
1. A weakness in one aspect of this chain will have consequences with respect to the usefulness of the information, products, and services provided.
2. It helps to reinforce the idea that inputs in the form of weather and climate events must be translated into user-specific products that aid climate-resilient decision making.
3. In the past, much investment in weather and climate services has been piecemeal, resulting in inefficiencies and a lack of sustainability in the ability of the system to perform in the medium and longer term.

FIGURE 2.3. WEATHER AND CLIMATE SERVICES VALUE CHAIN



[3] WMO Geneva November 10, 2014 press release.

FIGURE 2.4. TYPICAL ADVISORY SERVICES FOR CROP PRODUCTION AND MARKETING



For the information that the user needs to be effectively delivered, investments need to be made right along the chain, from observations and data through core science, to communications, modeling, forecasting and development of applications, and communications channels. Any weak link in the chain could lead to suboptimal results or a situation in which "potential value" does not convert into "real value."

FARMERS' DECISION MAKING UNDER A CHANGING CLIMATE

Farmers adapt to climate variability and change though climate advisories that reduce climate impacts (figure 2.4). Information assists farmers in deciding which agricultural technologies and adaptation mechanisms may be most useful in responding to weather variability and climate change (Wood et al. 2014).

Decision making in the agricultural sector can be categorized into strategic and tactical decisions. Strategic decisions require planning across seasons to multiple seasons (longer-term) to enhance productivity and profitability or minimize risk and reduce environmental impacts. These decisions include the selection of suitable varieties; setup of blocks and farm layout; size and type of equipment; tillage practices; choice of irrigation equipment and technology; establishment of grazing practices; purchase of fertilizers, herbicides, and other chemicals; harvesting equipment and scheduling; and forward marketing; and price contracts decisions.

Tactical (or shorter-term) decisions in crop production require planning decisions within the growing season or at subseasonal basis. Tactical decisions are those that must be made much more frequently, such as weekly and monthly to assist the strategic objectives of the farming operations. Examples of tactical decisions in farming systems include purchase or sale of livestock, timing of planting, irrigation scheduling, timing of fertilizer applications, chemical applications, and harvesting (table 2.1). A practical application of the design of agro-weather tools to aid decision making in Embu County is presented in box 2.2.

TABLE 2.1. TIME SCALES FOR TACTICAL AND STRATEGIC AGRICULTURAL MANAGEMENT DECISIONS

Decision Type	Climate System (Years)
Logistics (for example, scheduling of planting/harvest operations)	Intraseasonal (> 0.2)
Tactical crop management (for example, fertilizer/pesticide use)	Intraseasonal (0.2–0.5)
Crop type (for example, wheat or chickpeas)	Seasonal (0.5–1.0)
Crop sequence (for example, long or short fallows)	Interannual (0.5–2.0)
Crop rotation (for example, winter or summer crop)	Annual/biennial (1–2)
Crop industry (for example, grain or cotton, phase farming)	Decadal (~10)
Agricultural industry (for example, crop or pasture)	Interdecadal (10–20)
Land use (for example, agriculture or natural system)	Multidecadal (20+)
Land use and adaptation of current systems	Climate change

Source: Meinke and Stone 2005.

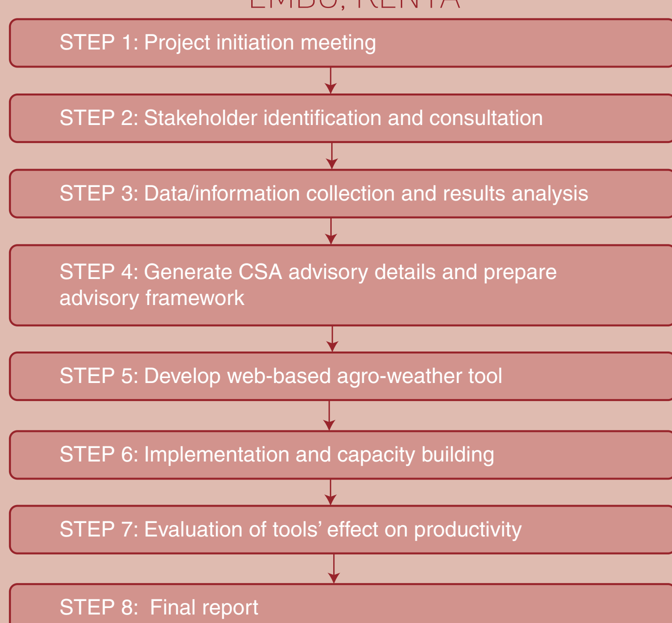
BOX 2.2. AGRO-WEATHER TOOLS FOR ADAPTING TO CLIMATE CHANGE FOR EMBU

The initial project-scoping mission involved substantial consultations with stakeholders and potential collaborators. A total of 63 farming institution representatives were consulted through side meetings and workshop. The smallholder farming community was also involved in a participatory process with a mission team validation meeting held in Embu County. This was aimed at assessing the institutional capacity, community needs and readiness to try different climate change adaptation strategies in their farming operations. Development of the Agroweather Decision Support followed a systematic process as outlined in figure B2.2.1. The consultative approach involving both the public and private sector ensures that the right climate information is delivered to the farmers.

CIS effectively enabled farmers to make appropriate decisions in their choice of varieties. It was highly useful in making and complementing recommendations about which farm inputs to use. It was used to good advantage by extension services and farmer organizations, resulting in higher rates of adoption of new varieties and practices. Because of the marked difference between project participants and nonparticipants, the interest that CIS stimulated among other producers generated benefits that spilled over into the entire local farming community.

The impacts of a failed season in which there was insufficient water to meet crop requirements, leading to lower yields despite increased labor inputs, were more pronounced on nonbeneficiaries, who were markedly less prepared to adapt to weather variability. CIS has a remarkable impact on crop yields and income. In Embu, farmers with access to agroweather information (beneficiaries) recorded an average maize yield of 970 kilograms (kg) per hectare compared with 210 kg per hectare for nonbeneficiaries. The average income from maize for the beneficiaries was 9,402 Kenya shillings (K Sh) compared with K Sh 3,918 for nonbeneficiaries (Braimoh et al. 2015).

FIGURE B2.2.1. SYSTEMATIC PARTICIPATORY APPROACH IN DEVELOPING AGRO-WEATHER DECISION SUPPORT SYSTEM IN EMBU, KENYA



CHAPTER THREE
FINDINGS FROM THE SURVEYS

The results reported in this chapter are for 29 climate information services (CIS) providers that completed the questionnaire and provided information through phone interviews or follow-up face-to-face meetings.

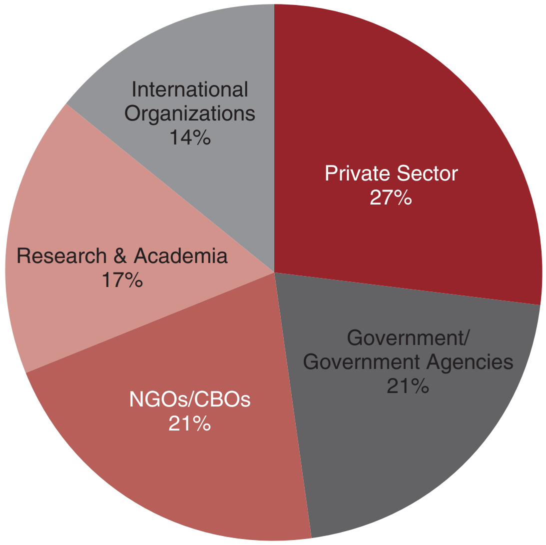
NATURE OF THE ORGANIZATION OF CIS PROVIDERS

Most respondents that completed the questionnaires were from private sector organizations, accounting for 27 percent of the service providers. Government agencies and NGOs/community-based organizations (CBOs) each accounted for 21 percent of the total; research and academia constituted 17 percent whereas international organizations constituted 14 percent, as shown in the figure 3.1.

CIS providers relate their organizational structure, functions, and services to a guiding mandate, vision, or mission and related goals and objectives. Apparent in the mission statements are motivations such as safety of citizens, protection of property, support for economic growth and efficiency, and core activities within climate services such as adaptation and disaster risk reduction. These objectives guide the production and delivery components of CIS, which are apparently guided by the priorities and boundaries of the communities they are required and intended to serve.

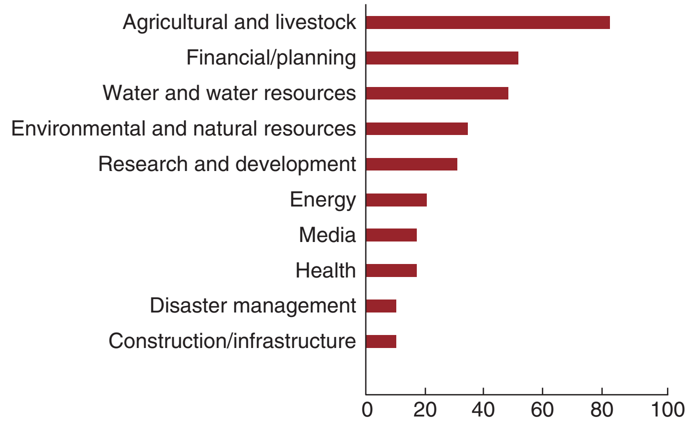
Climate information is primarily an international public good and governments have a central role in its management (Lúcio and Head 2012). Consequently, the Kenya Meteorological Department (KMD) is the national meteorological agency mandated to collect and store climate data in the country. KMD is also charged with coordinating and managing the climate information provision framework. Currently, KMD undertakes data collection through its own climate observing stations and also through collaboration with other institutions and volunteer observers. However, in the context of CIS there are other producers, for example, the Intergovernmental Authority on Development Climate Prediction and Applications Center (ICPAC) and the African Centre of Meteorological Applications for Development (ACMAD). Some other organizations are producers and as well as users: the Food and Agriculture Organization (of the UN)

FIGURE 3.1. NATURE OF ORGANIZATIONS PROVIDING CLIMATE INFORMATION SERVICES



Source: Field surveys.

FIGURE 3.2. SECTORAL FOCUS BY THE CIS PROVIDERS (%)



Source: Field surveys.

(FAO), Alliance for a Green Revolution in Africa (AGRA), Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), Farming and Early Warning Network (FEWSNET), International Livestock Research Institute (ILRI), Index-Based Livestock Insurance (IBLI), Consortium of International Agricultural Centers (CGIAR), Climate Change, Agriculture and Food Security (CCAFS), and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

SECTORAL FOCUS

The survey shows that the CIS providers cover diverse sectors with more than 83 percent focusing on agriculture and livestock. This is reasonable, because agriculture is one of the sectors most affected by climate change. Some 52 percent focus on financial planning including financial services for agricultural production, processing, and marketing. This service involves identifying, quantifying, pricing, and mitigating the financial risk associated with climate change impacts. Relevant and accurate information input is required on all parameters that are relevant for risk management and proper decision making.

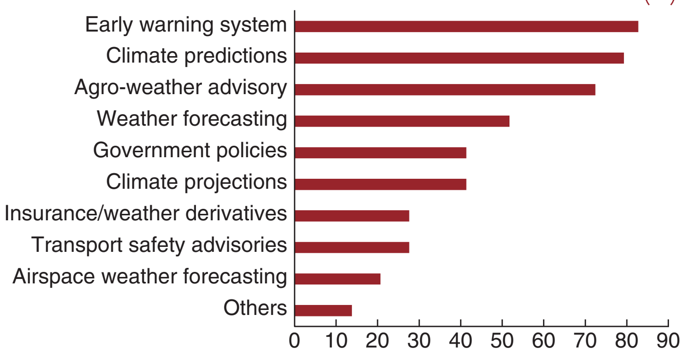
The survey further reveals that 48 percent and 34 percent of CIS providers, respectively, focus strongly on water, and the environment and natural resources. Research and development also attract a relatively strong focus from 31 percent of the CIS providers, whereas focus of the other sectors range from 10 percent for construction/infrastructure to 21 percent for energy (figure 3.2). This result suggests the multisectoral impacts of weather conditions and climate variability and also the multisectoral response of the CIS providers in helping different sectors adapt to weather variability.

KMD and the National Drought Management Development Authority (NDMA) provide services for all the 11 sectors identified in the survey; Global Climate and Adaptation Partnership and Geo Envigro Limited each service six sectors; Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa (CHIESA), Pan Africa Climate Justice Alliance (PACJA), and the Regional Centre for Mapping of Resources for Development (RCMRD) each service five sectors. The Agricultural Sector Development Support Programme (ASDSP), FEWSNET, CARE International, and NDMA each service four sectors, whereas the remaining service providers focus on one to three sectors.

CIS SERVICE PORTFOLIO

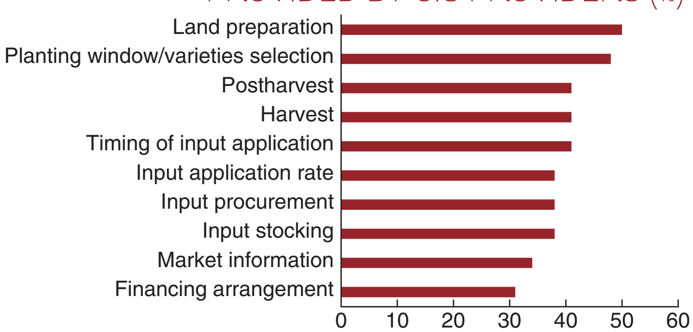
Because of increased public interest in and the need for climate and weather information across sectors, the CIS field in Kenya is dynamic with varying information needs targeted to different sectors. Thus, the CIS providers serve a diverse community of users with sector-specific climate information (figure 3.3). There is a reasonably high level

FIGURE 3.3. PRODUCTS/SERVICES OFFERED BY CIS PROVIDERS (%)



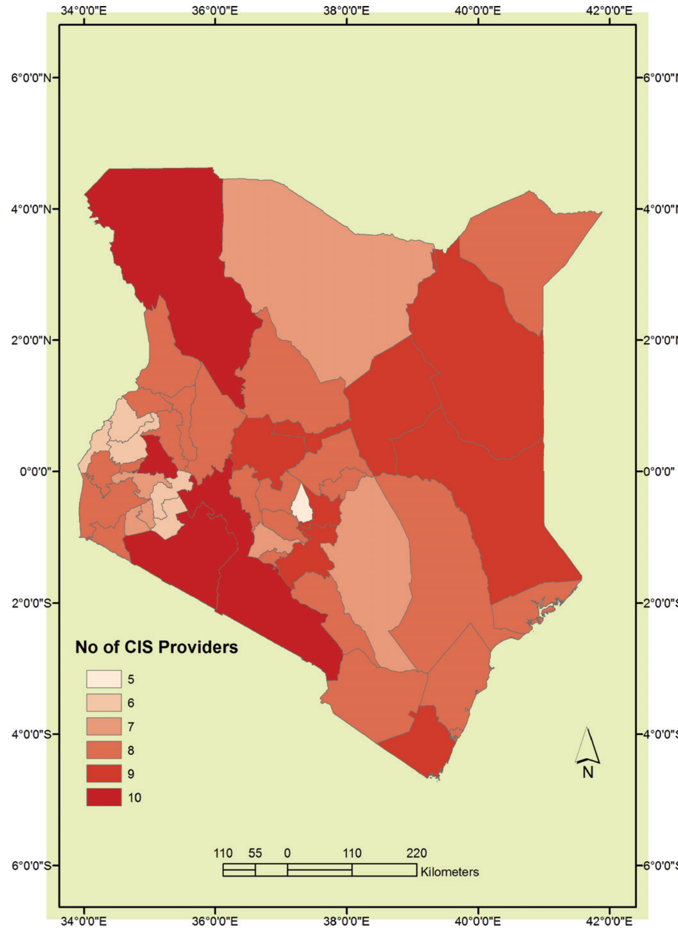
Source: Field surveys.

FIGURE 3.4. AGRO-WEATHER ADVISORIES PROVIDED BY CIS PROVIDERS (%)



Source: Field surveys.

FIGURE 3.5. CIS PROVIDERS' COVERAGE OF KENYA COUNTIES



Source: Field surveys.

of differentiation of climate and weather products and services offered in Kenya. Early warning systems and predictions stand out as the major products/services offered by 77 to 80 percent of the service providers. Next are agro-weather information services (72 percent), whereas half of the CIS providers work in weather forecasting. However, early warning systems and predictions also serve in areas such as farm operations and food security; therefore, the percentages indicated for agro-weather services could in reality be higher than indicated. It is noteworthy that some 41 percent of the CIS providers provide climate and weather advisories for general government policies and decision-making and climate projections, whereas 28 percent of the providers each service the insurance derivatives and transport safety advisory sectors.

With respect to agro-weather advisories, the survey indicates that CIS providers reasonably cover the various stages of crop production and marketing (figure 3.4). Only 30 percent of the CIS providers addressed financing, whereas half of the providers addressed land preparation.

All Kenya counties are covered by at least five CIS providers (figure 3.5). Kajiado, Narok, Nandi, and Turkana counties are covered by a maximum of 10 CIS providers (figure 3.5). Six CIS providers cover Bomet, Bungoma, Busia, Kakamega, Kericho, Kirinyaga, Nyandarua, and Nyeri counties. Some seven to nine CIS providers cover the remaining counties. Only two CIS providers (KMD and RCMRD) cover all the counties. Note, however, that the presence of CIS providers in a county does not automatically imply that all farmers who are in need of services are reached or are able to access them. Also, presence does not imply that relevant services of appropriate quality are delivered to users.

Most of the CIS providers do not have an effective mechanism with which to track their users. Under this condition,

TABLE 3.1. NUMBER OF FARMERS REACHED BY CIS PROVIDERS

CIS Provider	No. of Farmers
CCAFS	700
Agricultural Sector Development Support Program	45,869
CARE International (Adaptation Learning Program)	293,250
Agriculture and Climate Risk Enterprise Limited Ltd. (ACRE)	461,609
Adaptation (ADA) Consortium	1,466,100

Source: Field surveys.

providing feedback to enhance the utility of climate information is critically curtailed. Only five CIS providers provided data on the number of users reached (table 3.1).

CLIMATE AND WEATHER DATA

CIS is dependent on data, from both observations and numerical modeling. The starting point in the development of credible climate information for the end user is in receiving weather, climate, and other sector-specific data of appropriate spatial and temporal resolution that, when processed and integrated with local knowledge, can prove vital for decision making by the end users.

The study found that the CIS providers use radar, satellite data, and in situ manual and automated weather observations or a combination of these data sources (table 3.2). Apart from one private sector player that has developed its own automated weather station in the areas of high agricultural potential in the country, others are either in direct partnership with KMD in codeveloping climate information services/products or are indirectly using the data produced by KMD (box 3.1). By virtue of being regional bodies, others are by default working with KMD in jointly developing climate services.

Satellite data were found to be the preferred source or starting point in the development of products by major consulting climate information service providers. The free accessibility of these data contributes to shorter lead time in developing climate information products and services. However, index-based insurance service providers consider

TABLE 3.2. TYPES OF CLIMATE DATA USED BY CIS PROVIDERS

Data Type	Percentage
Radar	7
Satellite	52
In situ weather station	59

Source: Field surveys.

satellite-based weather data less precise than station-based weather data, a factor that raises premiums for station-based weather-sourced index-based insurance cover. Two service providers have installed ground satellite receivers for rapid access of satellite data from multiple space channels. KMD data are used by the majority for the following three reasons:

- Users have great confidence in ground truth data provided by KMD.
- KMD remains the referral source of climate data in the country, given that it is mandated by law to archive station-based climate data for the country.
- Some providers have only limited technical capacity in processing and analyzing satellite data.

CIS providers use data owned by various organizations. From the survey, 59 percent of the data used are owned by KMD and international organizations and CIS providers each own 45 percent (table 3.3). Thus, 55 percent of the CIS providers are purveyors that do not produce their own climate data, but add value to data already available from other sources.

Data collected undergo a variety of processing to yield sector-specific information. Processes involved differ depending on required outputs. CIS providers generally use more than one source in the processing of data. Some 79 percent of the interviewed organizations employ expert consultation,[4] 66 percent of the organizations consult with stakeholders, and 55 percent use focused discussion groups, whereas 52 percent of the CIS providers use modeling. Participatory approaches involving focus group discussion, stakeholder, and expert consultations

[4] Experts are those called in to consult based on their qualifications in the particular field, for example, agro-meteorologists, who can help interpret certain information received; stakeholders are those organizations or groups that have interest in the same information that will be derived from the data for similar or other uses.

BOX 3.1. WEATHER DATA COLLECTION IN KENYA

KMD has the largest weather infrastructure operation and maintains 36 synoptic stations countrywide that provide data on rainfall, minimum and maximum temperatures, wind speed and direction, air pressure, soil temperature, solar radiation, sunshine duration, relative humidity, evaporation, and cloud cover. It also has four marine tidal gauges with automatic meteorological sensors to monitor ocean tides and waves, including tsunamis. The data collected can also be used to study sea level rise associated with global warming. These data are crucial in providing information to support decision making in adaptation planning for coastal zone management.

There are other specialized observing stations operated by KMD that include 24 automatic weather stations (AWSs) that automatically record climate data and transmit them to receiving stations at KMD; 3 airport weather observing systems (AWOSs) at Jomo Kenyatta International Airport, Wilson Airport, and Mombasa International Airport that are able to detect and monitor hazards associated with extreme weather events; 17 hydro-meteorological automatic weather stations that have been installed in water catchments; 4 lightning and thunderstorm detection systems at Nairobi, Mombasa, Kisumu, and Eldoret to provide severe weather warnings, especially for aviation safety. KMD in collaboration with other international climate centers also operates 3 satellite receiving stations, 2 for Meteosat Second Generation (MSG) and 1 for the National Oceanic and Atmospheric Administration (NOAA) satellites, that receive global data on large-scale systems such as sea surface temperatures and wind fields. Every day, massive amounts of data are collected and stored at Kenya Meteorological Department. Unfortunately, the general public for whose benefit the weather services are offered have generally remained unaware of the services.

KMD has been the only national institution that has provided climate information for a long period but new initiatives have been established within the past few years owing to Kenya's relative advantage in establishing robust and dynamic private sector–driven climate information services. This is also supported by the existence of a stable national metrological agency rich in historical climate and weather data and the presence of regional meteorological agencies whose headquarters are in Nairobi, such as the Intergovernmental Authority of Development Climate Prediction and Applications Centre (ICPAC) and Regional Centre for Mapping of Resources for Development.

Apart from KMD, there are observers (individuals or institutions) who make climate notations voluntarily and transmit the data to KMD for use and storage. The majority of these observers collect rainfall data only because of the simplicity of doing so. A few also take temperature measurements. At present, there are about 3,000 volunteer observers registered by KMD who are located in various parts of the country, although not all of them collect and transmit the data to KMD on a regular basis as required. These data form a very useful supplement to the normal climate observation network because they increase the coverage of rainfall data that is critical for assessment of climate risks, especially for the agriculture and water sectors.

TABLE 3.3. OWNERSHIP OF THE DATA USED BY CIS PROVIDERS

Owner	Percentage
International organizations	45
CIS providers	45
KMD	59

Source: Field surveys.

(55 percent to 79 percent) are the most preferred methods (table 3.4). The level of participation by the users depends on the product and scope of services from the CIS provider. Service providers who have close collaboration with relevant partners and those who encourage strong participation by the end users (community representatives) have a wider geographic coverage that includes all the 47 counties in Kenya.

TABLE 3.4. APPROACHES USED IN DATA PROCESSING

Approach	Percentage
Expert consultation	79
Stakeholder consultation	66
Focus group discussion	55
Modeling	52
Others	17

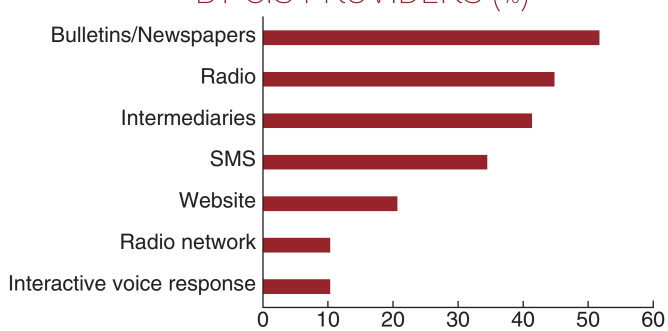
Source: Field surveys.

The survey noted that there was no framework for the evaluation of data quality used by providers and the CIS derived from the data. CIS providers do not label their products nor do they specify the methodology used in deriving their products and services. Because farmers are not climate experts, it is therefore difficult for them to ascertain the quality and probable value of the information used for decision making.

CLIMATE INFORMATION SERVICES DISSEMINATION METHODS

The benefit of a CIS is realized when it is used effectively for decision making. The CIS providers use several media to disseminate their services. The most common medium is bulletin/newspaper, used by 52 percent of the providers (figure 3.6). This is known to work well in project-type service provision but adoption may be negligible beyond the pilots. Radio is the next most common medium, used by 45 percent, whereas intermediaries are used by 41 percent of the CIS providers. Intermediaries refer to brokers between scientists/service providers and farmers, translating and adding value to agronomic and economic information of use in agricultural management decision making. It has been established that this intermediary model is the most effective mode of disseminating climate information. The policy implication should be to integrate "climate extension" into the current extension service/system. Short message services (SMS) are employed by 34 percent of the providers, website by 21 percent and radio network and interactive voice response system (IVRS) each by 10 percent. The relatively low frequency of SMS, websites, and IVRS suggests significant opportunity to expand the use of modern information and communication technologies (ICT) for higher market penetration. Brokers can then be encouraged to use them as sources of the information they disseminate.

FIGURE 3.6. COMMUNICATION MEDIA USED BY CIS PROVIDERS (%)



Source: Field surveys.

ADA Consortium provides a breakdown of dissemination methods to the estimated 1.5 million served by the project in five counties: Makueni, Kitui, Isiolo, Garissa, and Wajir. Table 3.5 indicates that majority of the users (77 percent) are reached through the radio across the five counties, followed by bulletin (11 percent), SMS (7 percent), and public *barazas* (5 percent).

Public *barazas* are face-to-face public community gatherings instigated by village officials for the purpose of attentive discussions. The primary purpose is public awareness creation, targeting specific groups and communities. Through *barazas*, the communities become aware and informed about their vulnerability and the measures they can take to proactively adapt to climate change. Public *barazas* tend to increase enthusiasm and support, stimulate community action, and mobilize local knowledge and resources.

The choice of the media should always be end user centered, taking into consideration the vulnerable groups, especially women, people living with disability, the elderly, and nomads in remote areas. Ignoring the roles, activities, and relationships of the end user at all stages may leave potential users underserved. Channels used must be accessible and have user-friendly attributes such as timeliness, accuracy, reliability, ease of use, depth of content, and language (see box 3.2).

TABLE 3.5. MEDIA USED BY ADA CONSORTIUM IN REACHING FARMERS

County	Radio	Bulletin	SMS	Public *Barazas*	Total
Makueni	304,060	59,940	34,800	18,000	416,800
Kitui	85,000	96,000	69,300	24,000	274,300
Isiolo	50,000	-	-	35,000	85,000
Garissa	270,000	-	-	-	270,000
Wajir	420,000	-	-	-	420,000
Total	**1,129,060**	**155,940**	**104,100**	**77,000**	**1,466,100**

Source: ADA Consortium.

BOX 3.2. SOURCES OF AGRO-WEATHER INFORMATION IN EMBU COUNTY, KENYA

The pilot project enlisted the participation of 4,500 farmers who were stratified into four categories according to the crop of interest—tea, coffee, sorghum, and maize and beans (maize is usually intercropped with beans). Fourteen sources of agro-weather information available to the beneficiaries were identified (see Table B.3.2.1). The farmers surveyed identified extension agents, radio broadcasts, and mobile phones as the most important. The multiple sources of information used by farmers suggested the need for a strategy that employs a combination of modern and traditional ICT. The information is likely to have more value if it was communicated through extension agents or contacts that farmers already know and trust. The beneficiaries of CIS indicated that the information provided improved use of farm resources, changed planting and harvesting practices, and was effectively used to prevent pest and disease attacks. The project results in general saw significant differences emerge between beneficiaries and a nonbeneficiary control group, with the mean score of the beneficiary group higher than the nonbeneficiary group.

TABLE B3.2.1. SOURCES OF AGRO-WEATHER INFORMATION IN EMBU, KENYA

Source	Percent of farmers
Extension Officers	66
Input Dealers	20
University	6
NGO	9
National Agricultural Research Organizations*	11
TV	27
Radio	71
Faith Based Organizations	21
Internet	8
Cell phone/SMS	53
Interactive Voice Response	30
Newsletter/Bulletin	63
Newspaper	12
Other Farmers	44

*This refers to the Kenya Agricultural and Livestock Research Organization (KARLO).

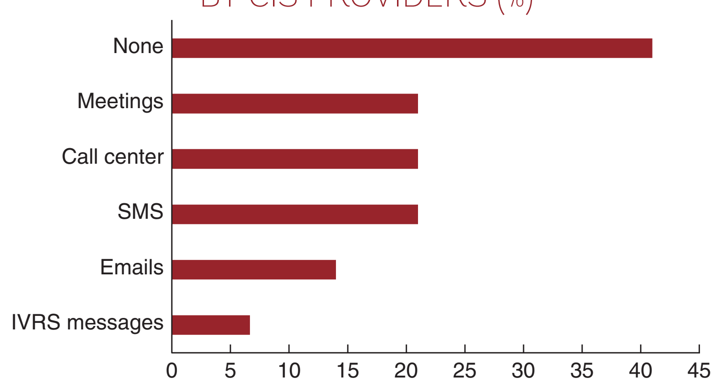
Source: Braimoh et al. 2015

CARE International and the Adaptation Consortium employing participatory scenario planning (PSP) are the two prominent institutions building capacity to interpret seasonal forecasts and disseminate climate information and services in a more user-friendly manner. Involvement of government agencies, such as the extension services, in dissemination of agro-weather information, has been found to legitimize the content owing to the authority conferred on government officers.

Feedback is the part of the receiver's response that is communicated back to the sender and takes a variety of forms. Feedback provides the sender with a way of monitoring how the message is being decoded and received by the target audience. It is the final link in the chain of the communication process. Service providers should be interested in the feedback from the end user so that the services can be improved.

This study indicates that SMS, meetings, and call centers are the primary feedback mechanisms employed by the CIS providers (21 percent each). CIS providers also use e-mails (14 percent) and IVRS (7 percent). The fact that the majority of the CIS providers (41 percent) do not use any feedback mechanism suggests the absence of bidirectional information exchange between providers and users to optimize recommendations, advisories, and alerts (figure 3.7). A more interactive information environment can markedly influence the accuracy of recommendations

FIGURE 3.7. FEEDBACK MECHANISM USED BY CIS PROVIDERS (%)



Source: Field survey.

BOX 3.3. CIS KNOWLEDGE AND SHARING WORKSHOP IN NAIROBI, JUNE 23, 2015

The workshop, attended by about 70 people from various sectors, generated a wealth of information some of which are summarized here.

- » Mainstreaming CIS into sector and development planning processes is critical to fully realize the benefits of climate services.
- » Climate information coupled with agro-advisory services offers great potential to manage climate related risks and enhances adaptive capacity
- » Historical climate information has great value to farmers and relates well to other products issued by KMD and forms a basis for understanding forecasts
- » Weak collaborations among relevant institutions is a major barrier for effective climate service provision
- » Resources are grossly insufficient for designing and disseminating new ideas
- » Partnerships involving providers, intermediaries and users are important.
- » Opportunities abound for the private sector to play a useful role in many aspects of the climate services value chain.
- » Public/private sector partnership can significantly increase the level of investment for CIS
- » Systematic two-way communication channels helps to understand and convey user needs to CIS providers and meaningfully present tailored climate information and its uncertainties to users, including the most vulnerable groups.
- » Continued engagement between multiple stakeholders is essential for interactive learning, effective communication of climate information, and its translations in specific contexts.
- » Appropriate advocacy on climate change issues and participatory approaches in the design of climate information products and services
- » Policies and regulations for CIS in Kenya need an urgent review.

and hence increase the utility of CIS (see some of the points in box 3.3).

BUSINESS APPROACH

The survey identifies five business-operating models in order of increasing autonomy, namely, public departmental unit; public body; private but not profit oriented; private and profit oriented; and international organizations (table 3.6).[5]

KMD, NDMA, and WRMA (10 percent), operating under the direct control of the government ministries, are the only public departmental unit in the survey. It has no autonomy and is primarily financed by the state budget, delivering noncommercial services to citizens or other public sector bodies. Although the public department model is straightforward to implement, there is the problem of monopoly with respect to a data observation network. It is also subject to high fiscal cost and lack of alternative sources of revenue and adequate funding to support capital and recurrent expenditures. There is little freedom or incentive to compete in commercial markets, and activities are based on standard government procedures on issues such as procurement. Limited and unreliable public financing make long-term investment decisions difficult, and could create a downward spiral that results in reduced staffing, inability to maintain observation networks, a limited capacity to innovate, low organizational incentives, and poor service delivery (Rogers and Tsirkunov 2013).

Six service providers (20 percent) operate the public body model. These organizations face less political and hierarchical influence and have more operational and managerial freedom. They supplement state budgets with grants and some earn revenues from service delivery. Although there is some autonomy compared with a public department, the public model is difficult to implement unless it is part of a governmentwide reform. Government entities

[5] **Departmental units** are hierarchical units operating under direct control of the corresponding minister, who has direct political control and ministerial responsibility for the unit's performance. **Public bodies** are entities that operate at arm's length from the central government. As a consequence, they face less political and hierarchical influence and have more operational and managerial freedom. **Privatized companies** operate under private law and have their own legal personality. **Not-for-profit organizations** do not earn their own revenues, but use the money earned in pursuing the organization's objectives. **For-profit organizations** operate freely in the market and generate their own revenues. Even though direct political control decreases through the privatization process, economic activities are controlled to a certain extent by regulations. **International organizations** are those set up by agreement between two or more states. They possess a nonstate entity with international legal personality separate from that of the states that established them. For the purpose of this work, international nongovernmental organizations are not classified in this category; they are regarded as private but not profit oriented because they are subject to the law of the country where they are incorporated.

TABLE 3.6. OPERATING MODELS OF THE CIS PROVIDERS[1]

	Operating Models				
Characteristics	**Public Departmental Unit**	**Public Body**	**Private but not Profit Oriented**	**Private and Profit Oriented**	**International Organization**
Government control	Directly controlled	Indirectly controlled	Indirectly controlled	Indirectly controlled	No, Host country agreements
Own legal entity	No	Partially or fully separate	Yes	Yes	Yes
Legal basis	Public law	Public law	Private law	Private law	Convention
Financing	State budget, grants	State budget, grants, own revenues	Grants, own revenues	Own revenues	Grants
Control mechanism	Direct political	Statutes, laws	Regulation	Regulation	Host country agreements
Ministerial responsibility	Yes	Partial	No	No	No
Autonomy	No	Yes	Yes	Yes	Yes
CIS Providers	KMD, NDMA, WRMA	ASDSP, KARLO, NDOC, NAFIS, UoN-Met, Maseno University/ University of Reading	CHIESA, KFWG, PACJA, ADA Consortium, UON-ICCA, CGA, ILRI (IBLI), CGIAR (CCAFS), FEWSNET, CARE International, TAHMO	ACRE, Upande, GCAP, Geo Envigro, Airtel Kilimo, Esoko, aWhere	RCMRD, ICRISAT, ICPAC

Note: CGA = Cereal Growers Association; GCAP = Global Climate Adaptation Partnership; KARLO = Kenya Agricultural Research and Livestock Organization; KFWG = Kenya Forest Working Group; NDOC = National Disaster Operation Centre; TAHMO = Trans-African Hydro-Meterorological Observatory; UON-ICAA = Institute for Climate Change and Adaptation; UoN-Met = Department of Meteorology, University of Nairobi; WRMA = Water Resource Management Authority.
[1]ASDSP is a government program but it is donor funded.

that are not accustomed to paying for services from other government departments will likely refuse to pay for meteorological and hydrological information, even though it may be essential for their operations.

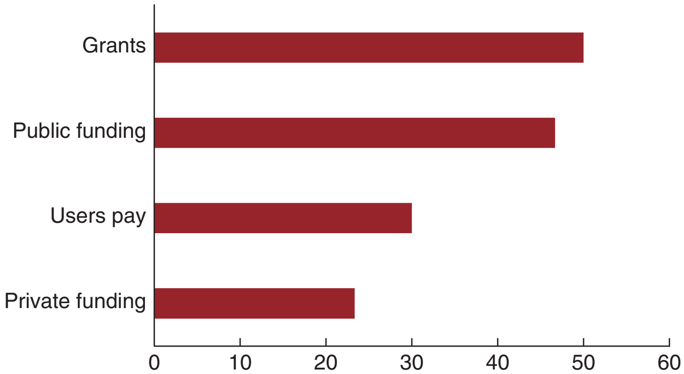
The largest proportion (37 percent) of the CIS providers are private but not profit oriented. They are essentially climate adaptation projects sponsored from abroad with limited life span. Some of the projects are meant to establish proof-of-concept or are implemented at the pilot scale, targeting a limited number of beneficiaries. Service provisions are inherently limited in scope, being specific to the overall goal of the project. A majority of these providers really do not provide services to users outside of their network/consortium.

The survey reveals that 23 percent of the CIS providers are privatized companies (profit oriented). They operate freely in the market and generate their own revenues. Even though privatized companies enjoy a high degree of autonomy, certain economic activities are controlled by government regulations. Given the public good nature of CIS benefits, full privatization may not provide optimal solution for effective CIS delivery. Purely market-based approaches are subject to low to moderate penetration, and can place a higher emphasis over commercial compared with technical criteria.

Three CIS providers (10 percent) are in the "International Organization" category: ICRISAT, ICPAC, and RCMRD. Funding comes principally from subventions from member organizations and other grants, and they do not generate revenues from CIS activities.

Figure 3.8 indicates that grants are by far the principal funding mechanism (52 percent), whereas private funds are

FIGURE 3.8. CIS PROVIDERS' INCOME SOURCES (%)



Source: Field surveys.

TABLE 3.7. COST STRUCTURE FOR SELECTED PUBLIC AND PRIVATE CIS PROVIDERS (%)

Cost Items	Public Department	Privatized Company
Data acquisition	10	5
Weather infrastructure	10	5
Data processing	10	50
System maintenance	20	20
CIS dissemination	50	20
Total	**100**	**100**

Source: Field surveys.

the least important for the CIS providers (23 percent). Only 30 percent of the providers generate revenue from CIS.

A closer look at the cost structures reveals different priorities for public and private CIS providers (table 3.7). For the public department model, half of the total running costs are expended on CIS dissemination, whereas for the privatized company these costs goes to data processing. This suggests that although the privatized entity spends less on data acquisition and weather infrastructure, it focuses most of its resources on adding value to its products and services. However, the reverse disconnect, in both cases, between processing and dissemination may need to be further interrogated.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

This study highlights development in the climate information services (CIS) field in Kenya in the past few years. There is a preponderance of private sector entities in the field relative to public institutions. The market is well differentiated with products and services targeting specific users. The diversity of data, services, and service delivery through different channels further provides evidence of a reasonable level of awareness of the importance of CIS for climate adaptation, not only in the agricultural sector but also in other sectors serving agriculture. It also suggests some understanding of the elements of the design and delivery of CIS products and delivery. However, an outstanding challenge is the absence of a framework to properly downscale CIS, evaluate the quality of the services, effectively deliver the downscaled services, and elicit relevant feedback from end users. There is also limited coordination in the CIS field with the implication that the much needed collaboration to enhance CIS design and delivery is missing. Sustainably scaling up CIS based on good science, improved governance, and appropriate business models is urgently required. Over the past few years since climate-smart agriculture (CSA) became a priority among development community, we are starting to see solutions emerge to each of these challenges, which taken together suggest a program for change. For the desired changes to take place there is an urgent need to address the policy, legal, and regulatory constraints that hinder innovation in CIS provision.

Given the findings from the study, five recommendations are made:

Recommendation 1: Improve technical and institutional capacity

There is a need for institutional reform to enable the Kenya Meteorological Department (KMD) to adjust to the new demands that climate change is placing on its services. There is a need to strengthen the legal and regulatory framework for KMD operations, including extending expertise within its management to include business development capabilities. New business models will need to be introduced and public-private partnerships enhanced (see Recommendation 5). As KMD is the main provider of CIS, its institutional performance can be enhanced through staff training, introducing business development experts, retraining, and professional development.

Observation infrastructure can be modernized by rehabilitating and reequipping meteorological, hydrological, and other networks, introducing more ground-based remote-sensing systems for nowcasting and very short-range weather forecasting, and increasing station-based observation equipment sufficient to effectively generate downscaled weather forecasts for subnational planning, and strengthening quality control of primary data by setting up calibration facilities. An effective service delivery strategy should be established that includes a platform that provides forecasts of the weather's impact on the basis of information available from numerical weather predictions, observations, and risk assessments. Modern media equipment enables KMD to create broadcast-quality bulletins. Mobile telephone–based applications are increasingly important to exploit the advances in mobile technology in the poorest and most vulnerable communities. There is also a need to develop a digital library of all climate-relevant information from all sectors to make the services more user oriented.

Recommendation 2: Improve coordination of CIS provision

There is a need for proper coordination of the various ongoing CIS processes. A starting point is to develop a web-based national database of climate service providers. The database should provide information on organization, sectorial focus, service portfolios, and other items for interested users. There is a need for networking CIS providers and key stakeholders for structured learning, including identifying and disseminating best practices; holding regular learning events; training; and periodic study tours. Public awareness campaigns to further highlight the benefits derived from climate information are required. Facilitation and brokerage (intermediation) of expertise will also be needed for complex projects. An approach to protect data ownership and equally eliminate barriers for effective exploitation of climate information is needed.

Recommendation 3: Establish CIS quality management system

At present there is no framework for the evaluation of climate services and climate information content, which might make it difficult for users to identify high-quality climate services. An accreditation and quality management system geared toward appropriate definition of climate services, setting standards, labeling, and validation is required. A technical peer review panel is required to carry out demand-driven desk reviews of CIS activities as needed and as relevant. This would help enhance project capacities and quality. Indicators for quality standards also need to be developed and adherence to the standards enforced. Effective CIS delivery also entails developing a two-way interaction between the services and the users to properly address users' needs and facilitate their decision making.

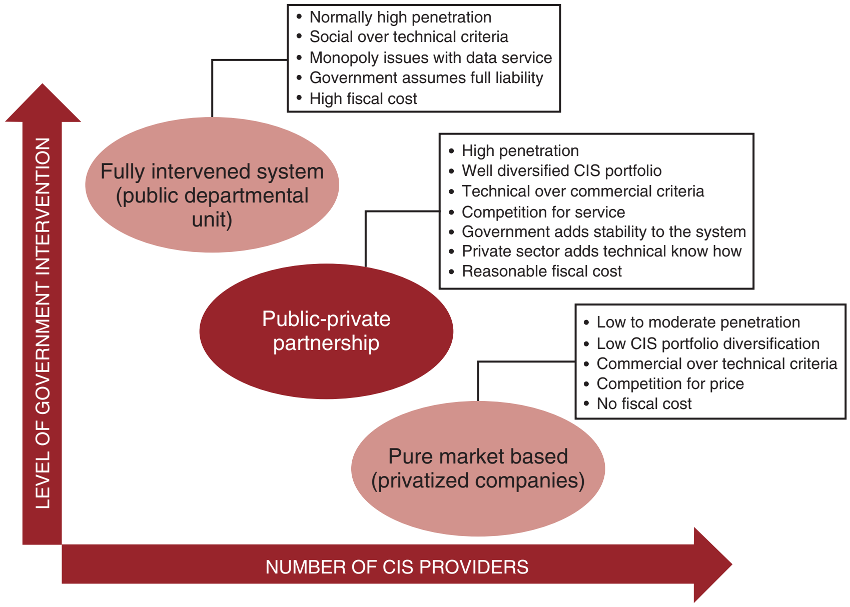
Recommendation 4: Foster codevelopment of CIS

There is greater need and demand for properly downscaled, relevant, timely climate information codesigned with end users. Given the knowledge-intensive nature of CIS provision, there is a need for actor-based platforms to facilitate knowledge acquisition, application, and feedback. Promoting the adoption of effective CIS will require well-designed, inclusive, and innovative systems with clear quality checks and balances. Priorities include strengthening farmers' knowledge of CIS benefits and facilitating their use in decision making. This will result in more robust CIS systems and user-led approaches. The use of colearning and comanagement strategies involving providers and users is one way to do this. Transdisciplinary, multidisciplinary research to support codevelopment of weather and climate services is also needed to enhance CIS knowledge integration. CIS providers and users working closely together will, in turn, lead to mutual accountability.

Recommendation 5: Create sustainable public-private partnership

Given the limitations of the pure governmentally intervened and pure market-based CIS provision models, it is important to test new approaches in a carefully designed public-private partnership (figure 4.1). Public-private partnerships involve long-term cooperation between at least one public and one private entity for the joint execution of CIS projects in which there is an exchange of

FIGURE 4.1. FEATURES OF FULLY INTERVENED, PURE MARKET-BASED, AND PUBLIC-PRIVATE PARTNERSHIP CIS



know-how and a sharing of risks in fulfilling public tasks. It helps to break the downward trend of underinvestment, poor infrastructure, deficient services, low visibility, and insufficient funding that are a threat to national meteorological services. Public-private partnerships have the potential to provide more efficient services through synergies and complementarities from both public and private strengths. Public-private partnerships could also lead to image enhancement for the current government monopoly models such as KMD. However, a successful transition from fully government to effective public-private agency requires a fundamental transformation in institutional culture and mechanisms for staffing and conducting business. This can be a significant challenge, although the benefits it can bring in terms of developing a culture of service delivery and user engagement are significant.

Although KMD should retain its central role in climate information management, giving priority to the provision of forecasts and warnings of severe weather, floods, and droughts to the private sector can contribute particular competencies in the form of innovative technology, design of resilient infrastructure, development and implementation of improved information systems, and the management of complex projects. A legal framework that includes data policy as a key element should be established to guide public-private partnership. A clear guideline is required on what should be provided as public goods service and what should be cost-recoverable services. The private sector can also produce and deliver valued added weather, climate, and environmental products and services, and promote their widest and most productive commercial application to enhance the efficiency of sectors that are sensitive to weather and climate variability.

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APPENDIX A
LIST OF CIS PROVIDERS

Service Provider	Website
Kenya Meteorological Department (KMD)	http://www.meteo.go.ke/
Agriculture and Climate Risk Enterprise Ltd. (ACRE)	http://acreafrica.com/
Upande Ltd	http://www.upande.com/
Global Climate Adaptation Partnership (GCAP)	http://www.climateadaptation.cc/
National Drought Management Authority (NDMA)	http://www.ndma.go.ke/
Regional Centre for Mapping of Resources for Development (RCMRD)	http://www.rcmrd.org/
Trans-African Hydro-Meteorological Observatory (TAHMO)	http://tahmo.org/about-tahmo/
Geo Envigro Ltd	http://www.geoenviagro.com/
Famine Early Warning Systems Network (FEWSNET)	http://www.fews.net/
Index-Based Livestock Insurance (IBLI)	http://ibli.ilri.org/
Cereal Growers Association (Progressive farmers)	http://www.cga.co.ke/
University of Reading/Maseno University	http://maseno.ac.ke/
Department of Meteorology, University of Nairobi (UoN-Met)	http://meteorology.uonbi.ac.ke/
Institute of Climate Change and Adaptation (UON-ICCA)	http://icca.uonbi.ac.ke/
Kenya Agricultural Livestock Research Organization (KALRO)	http://www.kalro.org/
Agricultural Sector Development Support Programme (ASDSP)	http://www.asdsp.co.ke
Esoko	https://esoko.com/
aWhere	http://www.awhere.com/
Water Resource Management Authority (WRMA)	http://www.wrma.or.ke/
Kenya Forest Working Group (KFWG)	http://theredddesk.org/countries/actors/kenya-forest-working-group
Airtel Kilimo	http://africa.airtel.com
National Disaster Operations Centre (NDOC)	http://www.ndoc.go.ke/
IGAD Climate Prediction and Applications Centre (ICPAC)	http://www.icpac.net/
Adaptation (ADA) Consortium	http://www.adaconsortium.org/
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	http://www.icrisat.org/
Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa (CHIESA)	http://chiesa.icipe.org/
Pan Africa Climate Justice Alliance (PACJA)	http://www.pacja.org/
National Farmers Information Service (NAFIS)	http://www.nafis.go.ke/
CARE International (Adaptation Learning Programme)	http://careclimatechange.org
Climate Change, Agriculture and Food Security (CCAFS) of the Consultative Group on International Agricultural Research (CGIAR)	https://ccafs.cgiar.org/

APPENDIX B
MATRIX OF CIS PROVIDERS AND COUNTIES OF PRESENCE

	Service Provider / County	1 Baringo	2 Bomet	3 Bungoma	4 Busia	5 Elgeyo Marakwet	6 Embu	7 Garissa	8 Homa Bay	9 Isiolo	10 Kajiado	11 Kakamega	12 Kericho	13 Kiambu	14 Kilifi	15 Kirinyaga	16 Kisii	17 Kisumu	18 Kitui	19 Kwale	20 Laikipia	21 Lamu	22 Machakos	23 Makueni	24 Mandera	25 Marsabit	26 Meru	27 Migori	28 Mombasa	29 Muranga	30 Nairobi	31 Nakuru	32 Nandi	33 Narok	34 Nyamira	35 Nyandarua	36 Nyeri	37 Samburu	38 Siaya	39 Taita Taveta	40 Tana River	41 Tharaka Nithi	42 Trans Nzoia	43 Turkana	44 Uasin Gishu	45 Vihiga	46 Wajir	47 West Pokot	Total presence
1	Kenya Meteorological Department (KMD)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	**47**
2	Agriculture and Climate Risk Enterprise Ltd. (ACRE)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	**47**
3	Upande Ltd										√																					√	√											√					**4**
4	National Drought Managemenet Authority (NDMA)	√				√	√	√	√	√	√				√					√	√	√	√	√	√		√	√	√	√	√	√	√	√				√	√	√	√	√	√	√	√	√	√	√	**33**
5	Regional Centre for Mapping of Resources for Development (RCMRD)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	**47**
6	Geo Envigro Ltd										√			√						√			√									√	√										√						7
7	Famine Early Warning Systems Network (FEWS NET)	√				√	√	√	√	√	√				√					√	√	√	√	√	√		√	√	√	√	√	√	√	√	√			√	√	√	√	√	√	√	√	√	√	√	33
8	International Livestock Research Institute (ILRI) (IBLI)							√		√																√																		√			√		**5**
9	Agricultural Sector Development Support Programme (ASDSP)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	**47**
10	Esoko	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	**47**
11	aWhere																		√																														**1**
12	CARE International (Adaptation Learning Programme)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	**47**
	No of presence	8	6	6	6	8	8	9	8	9	10	6	6	7	8	6	6	6	7	9	8	8	9	8	9	7	8	8	8	8	8	10	10	10	7	6	6	8	8	8	8	8	8	10	8	8	9	8	

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