ICPAC

CLIMATE INFORMATION AND NEEDS ASSESSMENT REPORT

KENYA

Project Title: **Bridging Climate Information Gaps to Strengthen Capacities for Climate Informed Decision-making**

Submitted by: African Technology Policy Studies Network (ATPS)
The Chancery Building, 8th Floor, Valley Road,
P.O. Box 10081-00100,
Nairobi, Kenya
Emails: executivedirector@atpsnet.org

Date: **December, 2017**

KENYA CLIMATE INFORMATION AND NEEDS ASSESSMENT

ACRONYMS AND ABBREVIATIONS

ACMAD: African Centre of Meteorological Applications for Development
CBOs: Community Based Organizations
CIS: Climate Information Services
CMO: County Meteorological Office
CSA: Climate Smart Agriculture
ENACTS: Enhancing National Climate Service Initiative
FAO: Food and Agriculture Organization
GDP: Gross Domestic Product
GOK: Government of Kenya
ICPAC: Intergovernmental Authority on Development Climate Prediction and Applications Centre
IMTR: Institute Meteorological Training and Research
KBS- Kenya Bureau of Statistics
KMD: Kenya Meteorological Department
NCCAP: National Climate Change Adaptation Plan
NDMA: National Drought Management Authority
NGOs: Non-Governmental Organization
RANET: Radio Internet
RMTC: Regional Meteorological Training Centre
US-FEWSNET: United State Famine Early Warning Systems Network
WBG: World Bank Group
WMO: World Meteorological Organization
WRMA: Water Resources Management Authority

Key Messages:-
Kenya has made huge strides in the provision of climate information, this can be seen in the recognition by the government and acting institutions on the importance of climate in development. Appropriate steps have been and continue to be put in place in order to streamline climate into development for a resilient nation and from the actions undertaken within the country it is evident that there is awareness on the need of climate information for a resilience society. This has brought together several players who act at different levels to fulfil and support the initiatives for the provision of CIS within the country and these include government agencies, non-government agencies, CBOs, NGOs, faith based organization, humanitarian agencies, international and regional development partners and others. All these work for the provision of CIS at various level to cover the dynamic nature of CIS needs in the country. However due to the dynamic nature of the climate needs, there is still much to be done to bridge the gaps for climate service provision.

A study conducted by the World Bank in 2016 (WG, 2016) showed that in Kenya CIS is not a single mandate of the KMD however the process is supported by a number of international development agencies, governmental institutions and agencies, nongovernmental organizations (NGOs), and private sector entities. The provision of climate information is very dynamic and the user needs and capacity required to fulfil such needs varies across the country. The various CIS providers focus on different sectors and different regions but despite all the efforts and collaboration much of work is still necessary. From the study the most prominent sector of application of climate information is for agricultural services.

The product and services provided and services by various CIS players targeting specific users include agriculture and livestock; early warning systems with a proportion that also serve agricultural purposes; agro-weather information services in support of tactical and strategic decision making; weather forecasting; climate advisories for general government policies and decision-making and climate projections; and some providers service the insurance derivatives and transport safety advisory sectors (WBG, 2014). The CIS intermediaries and providers are distributed all over the Kenya with a minimum of about five working within each of the 47 counties. However the spatial depth of their engagement varies.

There is reasonable level of awareness of the importance of CIS for climate adaptation especially seen in the policy and legal framework and the efforts of engagement of stakeholders in CIS related issues. However, an outstanding challenge is the absence of a framework to properly downscale CIS to the local and county level in accordance with the decentralization initiatives. There is also a challenge to 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 framework to enhance CIS design and delivery; sustainably scaling up CIS based on good science; improved governance; and set up of appropriate business models is required.

The country through the Kenya Meteorological Department has gone into an initiative for decentralizing climate information so as to reach the community level, through the establishment of County Meteorological Offices. This has come with many challenges and needs including technological needs, human resource needs, and financial needs. The country is also in full line in developing initiatives for climate resilient society, and much of the legal and operational frameworks are being implemented, including the climate change action plan. 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. With the emergence of climate-smart agriculture (CSA) priority among development community has been aroused, and this has supported the change process through addressing the rising challenges. 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

1. Introduction:-

Extreme weather events, largely droughts and to a lesser extent floods, influence economic growth of the country and with associated devastating impacts. The frequency and intensity of severe weather events has been noted to increase, and this is expected to increase with further increase as with climate change. Frequent drought and flood events result in crop losses, livestock and wildlife deaths, spikes in food prices, increased food insecurity and malnutrition for the poor, rural population displacement, and impact on urban water supply, and on energy generation (World Bank, 2014).

The government of Kenya recognizing the growing threat climate-related risks pose to its near- and long-term development prospects. Vision 2030 (GOK, 2007a) and Kenya's First Medium Term Plan (2008–2012) (GOK, 2008), Second Medium Term Plan (2013–2017) (GOK, 2013) acknowledge climate risk and the need to enhance capacity to manage it especially in reducing drought hazards (GOK, 2010). Kenya's 2012 National Climate Change Adaptation Plan (NCCAP) recognizes the key role of improving climate information and services to strengthen the adaptive capacity of communities through 'providing farmers and pastoralists with climate change-related information, and mainstreaming climate change into agricultural extension services. The NCCAP equally recognizes the vital importance of climate information services (CIS) to reduce 'vulnerability to disasters by using climate risk information in development planning and policy making; taking into consideration that more than 70 per cent of natural disasters in Kenya are related to extreme climate events.

The provision of climate information and the coordinating and managing the climate information provision framework in Kenya is mandated to the Kenya Meteorological Department (KMD) which is the national meteorological service provider (WBG 2016). Kenya meteorological department has a nationwide network and has recently decentralised its services to the county level, in conformity with the Kenya Constitution of 2010. The county meteorological offices are expected to contribute a lot in bringing climate services nearer to the community users, highly collaborating with county institutions, CIS intermediaries and bodies at the local levels.

Efforts to fulfil the climate service gaps in Kenya, has brought on board several groups and agencies, and these range from Research and academia institutions; NGOs/ CBOs; governmental agencies; private sector; and regional and international organizations who play an active role in the context of CIS. In collaboration with KMD, regional climate centres such as the Intergovernmental Authority on Development Climate Prediction and Applications Centre (ICPAC) and the African Centre of Meteorological Applications for Development (ACMAD) work to generate climate information for stake holders within the region. Some of the CIS providers act as both users and producers of climate information especially those whose work evolve around community engagement and development (WBG, 2016).

Although much efforts have been made in the provision of climate information in the country there is still gaps to fill especially in the technical capacity for production of user-oriented products, and communication and dissemination capacity. These can be attributed to the diversity of the CIS environment in Kenya, the lack of funding, lack of technical skills, and lack of appropriate frameworks for collaboration.

2. Brief description of key concepts:-

Weather and Climate: Climate in a narrow sense is usually defined as the average weather, 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 or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. Weather is the atmospheric condition in a given place, including variables such as temperature, rainfall, wind, or humidity. The well-known adage "climate is what you expect and weather is what you get" clarifies the difference between the climate and weather.

Climate change: refers to a significant variation in either the mean state of the climate or in its variability, persisting for an extended period of time (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 variability: refers to variations in the mean state of the climate on all temporal and spatial scales.

Climate information: These are knowledge generated to measure, understand and predict the climate and can be applied for mitigation and adaptation of climate related risk.

Climate services: Climate services can be understood as those activities that deal with generating and providing climate information to a wide range of users in order to support climate resilient development. Climate services provide individuals, organizations and socio-economic sectors with science-based information in a way that assists decision making to help them mitigate the risks and take advantage of the opportunities that come with climate variability and change. Such services require appropriate engagement along with an effective access mechanism and must respond to user needs (WMO 2014).

Climate change: Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

Climate variability: Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events.

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) or any other information that can be developed into solutions, and other services in relation to climate or responding to climate change for the benefit of society.

County: These are sub-administrative levels within Kenya, formerly derived from provinces and districts, and are 47 seven in number, established for the devolvement of Government services.

ADA Consortium: The Adaptation Consortium (Ada) is one of three components of the Strengthening Adaptation and Resilience to Climate Change in Kenya (Plus) (STARK+) financially supported by the UK Department for International Development. Working across five Arid and Semi-Arid counties (Kitui, Makueni, Isiolo, Wajiir and Garissa), to develop approaches for adaptation replicable in other counties and potentially elsewhere.

Climate intermediaries: These are institutions or representatives who come from multi-sector and act as a link between climate users and producers, they provide a network for dissemination of information and feedback on the services provided. These have been found to be important as they are usually able to create a network that can reach a multitude of users and also they can be able to breakdown the climate information from a technical form to a more user friendly form for decision making.

3. Review of Climate information needs and capacity in target Countries:-

3.1 Application of Climate Information and services

In Kenya the user needs for climate information vary and are very dynamic. It is not a situation of one size fits all in especially for most of the country. The sectors of concern for majority of CIS providers vary and are focused on Agricultural and livestock, Water and water resources, Financial/planning, Environmental and natural resources, Energy, Research and development, Health, Media, Construction/infrastructure, and Disaster management (WBG, 2016). The service and product portfolio for CIS in Kenya also varies focusing around Climate predictions, early warning system, weather forecasting, agro-weather advisory, climate projections, government policies, transport safety advisories, Insurance/weather derivatives, and airspace weather forecasting. Much of the CIS providers are involved with agriculture related sector and have services and products that focus on agro-weather advisories. This can be attributed to the importance of agriculture to the country and the impact of climate variability to agriculture.

A study conducted by the World Bank in 2016 (WG, 2016) on climate service providers in Kenya indicated that a total of CIS for 11 different sectors are spread all over the country, out of which, Eighty-three percent of them focus on agriculture and livestock; Approximately eighty 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 forty one percent of the CIS providers give climate advisories for general government policies and decision-making and climate projections, whereas twenty eight percent of the providers service the insurance derivatives and trans-port safety advisory sectors.

3.2 Communication/dissemination mechanisms

The CIS environment is vast and varies and therefore each climate information producer aims at providing information to the user in the appropriate form. The choice of the media should always be end user centred, 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.
The most common medium is bulletin/newspaper, 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, followed by the use of intermediaries. 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. Short message services (SMS), website, and radio network and interactive voice response system (IVRS) are also employed. 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. 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 KMD is implementing the concept of 'climate intermediaries' who are themselves users and also act as a bridge between the final users and the climate information provider. Intermediaries receive forecasts through SMS and work with the CDM to provide a network for dissemination of information and feedback on the services provided. Intermediaries are selected from across institutions and agencies with existing extensive reach including County Administrations and the Ministries of Agriculture, Livestock and Cooperation, as well as religious and community leaders and NGOs. The aim is to establish a network of approximately one intermediary for every 500 people in each county. 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. CARE International and the Adaptation Consortium are employing participatory scenario planning (PSP) which help in building capacity to interpret seasonal forecasts and disseminate climate information and services in a more user-friendly manner.

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. SMS, meetings, and call centers are the primary feedback mechanisms employed by the CIS providers. CIS providers also use e-mails and IVRS. Most of the CIS providers do not have an effective mechanism with which to track their users. Under this condition, providing feedback to enhance the utility of climate information is critically curtailed. The fact that the majority of the CIS providers do not use any feedback mechanism suggests the absence of bidirectional information exchange between providers and users to optimize recommendations, advisories, and alerts . A more interactive information environment can markedly influence the accuracy of recommendations

3.3 Climate Information Gaps

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). A gap analysis published by the International Research Institute for Climate and Society (IRI) and the Global Climate Observing System (GCOS) in 2005 explored the challenges in the application and user of climate information in detail and identified four key gaps: (i) gaps in integration of climate into policy; (ii) gaps in integration of climate into practice at scale; (iii) gaps in climate services; and (iv) gaps in climate data. Though this information was a while ago, the gaps it highlighted are still relevant today. However, availability of relevant and reliable climate information, particularly throughout rural Africa, is substantially limited in terms of availability and quality, and where available there is lack of awareness on the availability or application of such information (IRI, 2006; FAO 2008; Washington et al. 2006; IRI 2005; Dinku et al. 2011).

3.3.1 Technical Capacity

The arising issues of climate change and such concepts and idea as smart agriculture as well as development of new technology for monitoring climate information and for communication, has created a need that should be addressed for effective application of climate information. The knowledge on climate change issues although available but the skills especially in climate change adaptation and impact assessment are still limited. Climate change also bring with it opportunities in CIS provision especially in green technology implementation There is rise in new technology and sensors and these should be addressed as to calibration and test for quality. Some other areas of interest would be in improving the knowledge for the validation and testing of CIS information, and also in the improvement an development of CIS information including downscaling to the required user decision level

3.3.2 Human Resource Capacity

Kenya meteorological department has a diverse array of human resource specialised and focussed on various aspect of CIS provision. However from huge initiative to decentralise CIS to county level, and with 47 counties to be covered across the nation, this has created a challenge in the availability of human resource at the county levels, with many of the county offices not having adequate number of employees recommended for the provision of climate service. There is need to train CIS intermediaries on methods of application and generation and dissemination of user oriented climate information; and also to train volunteer observers and county climate officers on appropriate methods and techniques for collecting and dissemination of climate data and information. Human capacity has to be developed in such areas as the systematic observations of climate change using the existing National and county network including volunteer observers and community data monitors.

With newer demands rising for climate change information, there is need to train on new technologies for climate data acquisition, monitoring, analysis and modelling, and dissemination and user outreach. This also comes from the rise of such new technologies as Smart Agriculture Initiatives which require specialised information.

Therefore also still need to develop knowledge on climate change related issues, and sensitize such including development of urban emission inventories and carry out urban climate studies, air pollution modelling, monitoring and forecasting. The majority of climate scientists have the general knowledge of climate change. There is need for specialized training in aspects such as: Climate variability and change studies specialized training on climate change in areas such as impact assessments etc; Climate change model development and application; Specialized equipment maintenance and any other relevant courses.

3.3.3 Financial Capacity

Most of the CIS providers in Kenya can be categorised based on 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. The major sources of funding for CIS providers are Grants, Public funding, users pay, private funding

Considering that climate information is primarily an international public good and governments have a central role in its management (Lúcio and Head 2012). KMD which is operate under the direct control of the government ministries. It has no autonomy and is primarily financed by the state budget, and deliver non-commercial services to citizens or other public sector bodies. Government entities 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 main barrier to satisfactory implementation of the program is that KMD may not have adequate financial resources to establish stations in many areas of the country where communities can benefit most. This is due to lack of alternative sources of revenue and adequate funding to support capital and recurrent expenditures. 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). This also applies for other public departmental unit such as NDMA, KMS, WRMA.

The service providers that operate in the public body model 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. There are also the CIS providers are private but not profit oriented, majority of which are climate adaptation projects sponsored from abroad with limited life span. Some of these projects are meant as pilots, targeting a limited number of beneficiaries, with limited scope that are specific to the project goals.

Privatized companies (profit oriented) are also involved in CIS provision in the country, and these operate 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. Majority of international and regional players in the CIS provision in the country obtain funding from principally from subventions from member organizations and other grants, and they do not generate revenues from CIS activities.

Table 1 Climate information needs and capacity in target country

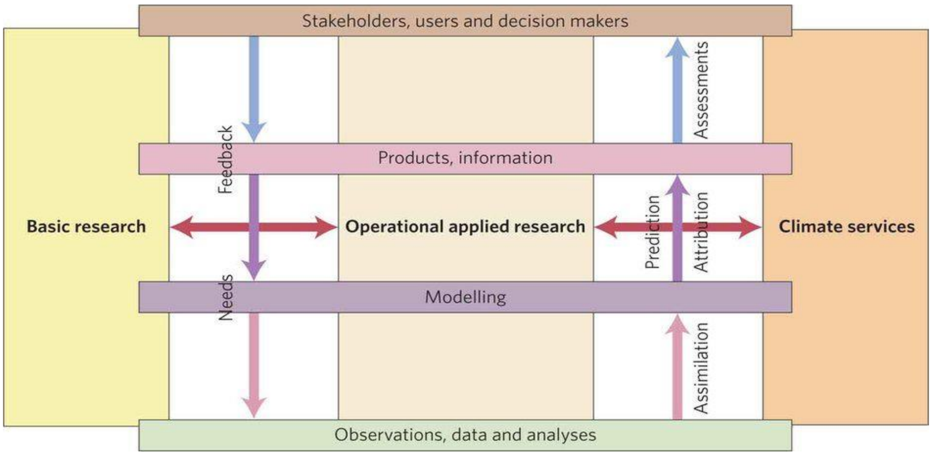
	Need	Existing situation	Specific needs/gaps
a)	Climate Information		
	• Availability and Access	Available at various time scales and at national and county level. Information include unique weather events and warning advisories, forecast at different time steps, trends and climatology are available. Much of the information at shorter time scale are yet to be implemented in many of the county offices Are accessed through bulletin, radio, sms, website and social media, email, phone call, television Limited tools for integrating climate information and local knowledge	Lack of use of modern integrated information system for information assessment, and dissemination. Develop framework for sharing of climate information and data among local producers Create tools and framework for integrating local climate knowledge and climate information services, and allowing easy access
	• Analysis and recording	Use of a variety of tools and methods for generation of climate information No common operational procedure for the generation of climate information especially at the local level. In the process of implementing ENACTS integrated framework No current set up framework for monitoring performance of climate information Majority of CIS users and providers are either in direct partnership with	Develop a framework for downscaling of climate information for local needs, and for monitoring the performance of the services. Develop procedures and implement tools for generation of user oriented climate information at the local level Provide tools for easy integration of climate information to enable decision making There was no framework for the evaluation of data quality used by providers and the

		KMD in codeveloping climate information services/products or are indirectly using the data produced by KMD. By virtue of being regional bodies, others are by default working with KMD in jointly developing climate services.	CIS derived from the data. CIS providers do not label Develop product and service catalogue and information including methods and data used in analysis
	• Weather monitoring	There are scares rainfall distribution in some areas especially in arid and semiarid lands Data rescue from obsolete media which lie at the local or private observers No framework for regular remittance of volunteer observer station	Improve the station network especially in arid and semi-arid lands Conduct data rescue to convert data from obsolete media to usable form Collect and provide means for training of volunteer community climate observer Revitalize local station and increase monitoring network Explore the use of satellite derived data sets and build capacity of climate users to use such
b)	Technical Capacity *(Skills)*	KMD limited computing facility computer used for numerical weather prediction. Limitation of computing capacity at the county and sub-county level Limited technical knowledge on new technology such as modern weather centres and tools. Limited knowledge on climate change information especially for impact assessment needs	Train on use and maintenance of modern equipment Training on methods including modelling Training in climate modelling, impact assessment and analysis including application of appropriate tools Training on
c)	Human Resource Capacity *(Enough workforce*)	Number is limited especially at the county level Limited skills on new technology and on development of new technology A large of the skilled staff are expected to retire in the recent year which is likely to increase the skill gap.	Support the engagement of more meteorologist and support staff especially at the county level Improvement of skill and knowledge on climate and weather related activities especially on new technologies, for production, and dissemination of climate information. Improve skills on climate change impact assessment Train staff on downscaling methods
d)	Financial Capacity	Most government institutions have no autonomy Much depended on government funding for provision of public services Some interagency climate services	Framework for valuation of CIS government and clear guidelines on cost Increase autonomy to allow space for alternative sourcing of funds and flexible decision making especially for long-term plans

		are not paid for by the government recipient institution	
e)	Infrastructural needs	Only three upper air monitoring station available and only one in operation	Support the development, revitalization an expansion of monitoring facilities across the country
f)	Technological needs *(Tools, equipment, software)*	Has a single mainframe computer used for numerical weather prediction There are limited computing facilities at the county level	Higher computing system for modelling and analysis Better integrated climate information monitoring system Improvement of the user of different ICT technology especially for communication of data and climate information
g)	Policy and regulatory needs	Established decentralisation plan CIS in Kenya have been handled without a coordinated CIS policy, legal and institutional framework and lack of standard operating procedures	No legal / institutional framework for collaboration in CIS management. Need to integrate "climate extension" into the current extension service/system
h)	Early warning Systems	Availability of early warning information through the efforts of CAP. Does not support much all are used for dissemination, especially ICT related avenues Based on inter-agency forums such as the Food security st	Promote the use of modern technology ICT Improve the early warning to the grassroots Expand the user-reach and also engage and improve the skills of local users Create awareness of the availability of the early warning information
i)	Monitoring of extreme weather events	These are efforts to set up a Common Alert Protocal, There are production of early warning information, for climate, hydrological and geological events. These are available through the KMD website The information is produced at the national level	Improve the communication of early events and apply more communication channels Generate local scale warning Integrate the early warning into the current available disaster risk network Employ tools for integration of early warning information for users at all level
j)	Dissemination mechanisms (from producers to users/End-users)	Many mechanisms are employed for CIS communication mainly through newsletters and bulletin, RANET, SMS, RVT, meetings and through CIS intermediaries The current platform is based on agency intervention and interaction	Need to explore more channels especially the use of ICT platform. Engage users in the design and implementation of CIS especially defining the specific-user needs. Allow for Implement a platform that allows for effective, interaction, monitoring and user feedback

4. Climate Information System:-

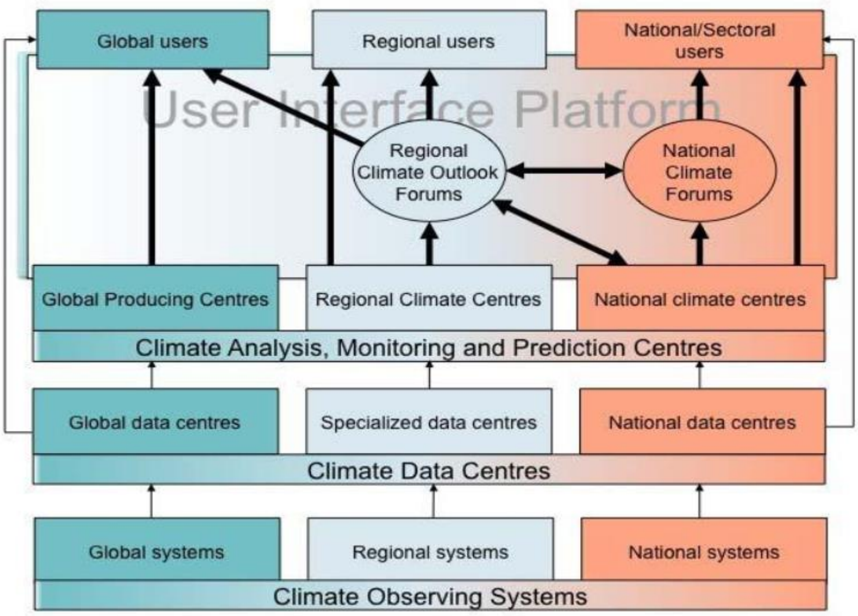
A climate information system helps inform decision-makers about what is happening and why, and what the immediate prospects are according to Trenberth (2008). Kindly use the diagram below with the description to define or establish a climate information system for the target countries. The diagram shows a schematic of the flow of the climate information system, as basic research feeds into applied and operational research and the development of climate services. The system is built on the climate observing system that includes the analysis and assimilation of data using models to produce analyses and fields for initializing models; the use of models for attribution and prediction and with all the information assessed and assembled into products and information that are disseminated to users. The users in turn provide feedback on their needs and how to improve information.



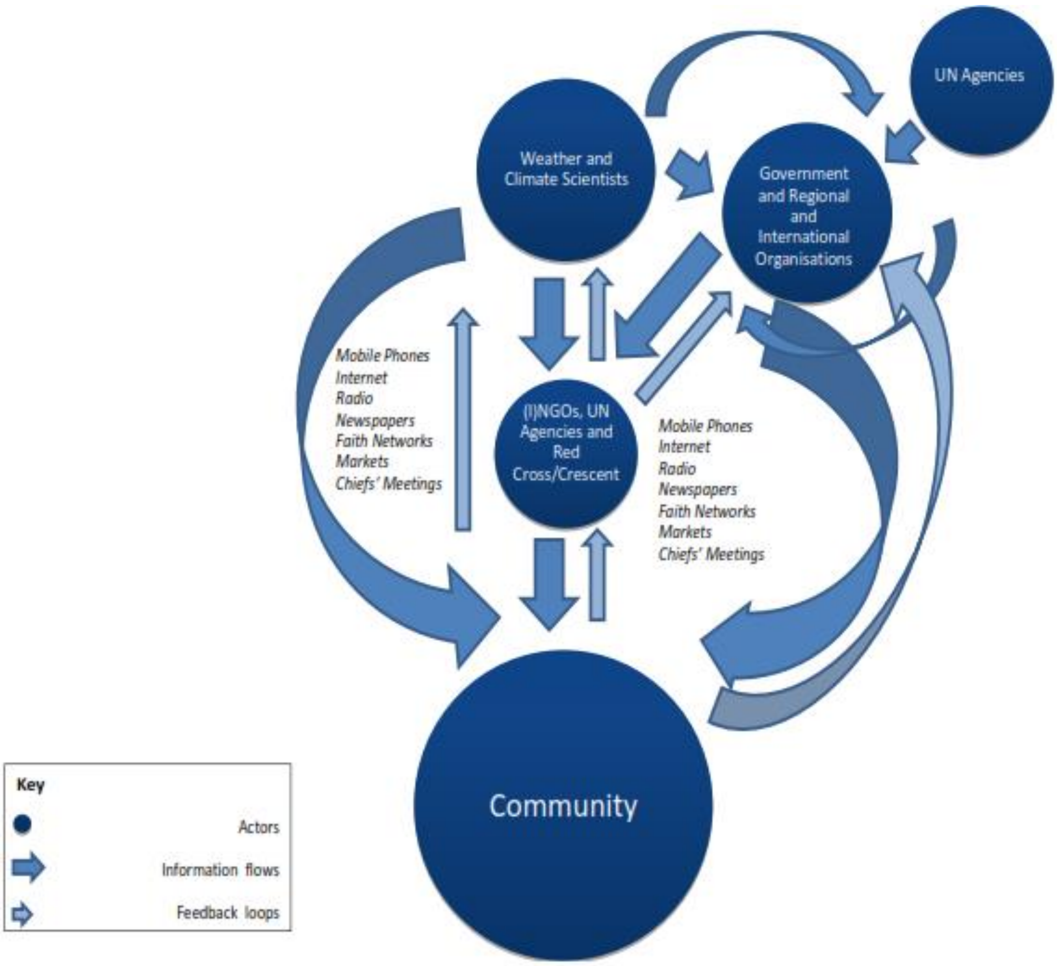
Climate information system (Adopted from Trenberth, 2008; Trenberth et al., 2016)

The Kenya Meteorological Department (KMD), which is nationally mandated body to provide climate information services (CIS) in Kenya and to provide framework to achieve such. The Kenya Meteorological Department (KMD) derives its mandate from the World Meteorological Organization (WMO) Convention, which is to provide accurate, timely weather and Climate Information Services (CIS). Education and training including research and development are additional functions designated by WMO to KMD. The mandate of KMD is to provide meteorological, hydrological and related services in support of relevant national needs, including safety of life and protection of property, safeguarding the environment and contributing to sustainable development, as well as to meeting international commitments and contributing to international cooperation which is derived from the world meteorological organisation (WMO) convention. KMD has made steps in decentralizing climate information services to the county levels and these are aimed at providing localised and user specific information. County meteorological offices are expected to implement the mission of KMD at county level.

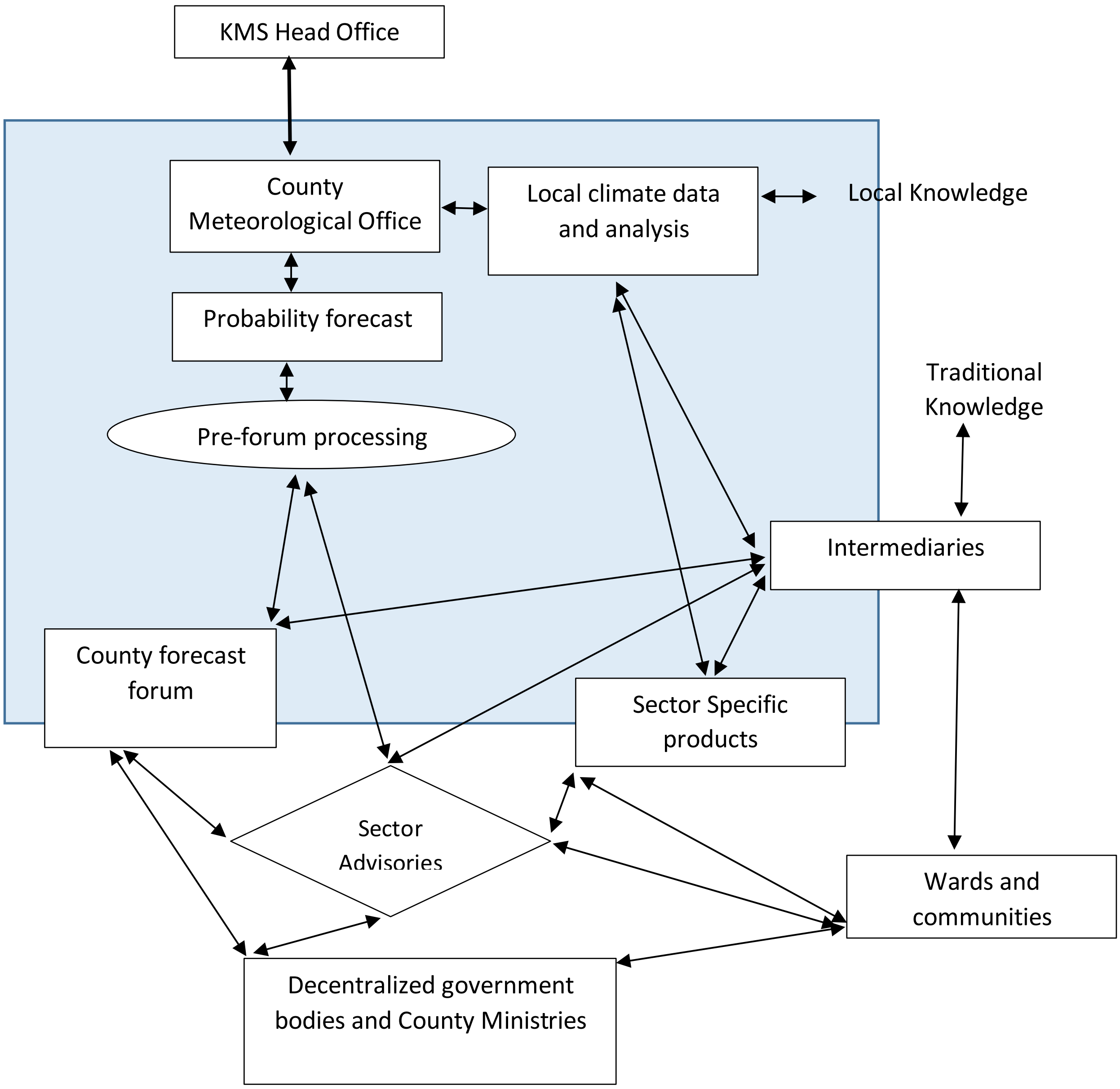
Development of weather and climate products is done at different levels, including global, regional, national and local scales. At the national level, KMD develops the products at its headquarters in Nairobi. These national-level products are released to County Meteorological Office (CMO) as needed for use at the county level. The CMO has the role of downscaling national-level products to address local needs. Weather and climate products include: probabilistic weather forecasts, ranging from short-term (daily, weekly), medium-term (monthly) and long-term (seasonal and annual); rain onset, cessation and distribution; early warning advisories; and climate summaries and normals. The CMO uses historical climate data and local knowledge of climate variability to downscale the national monthly and seasonal forecasts to develop a forecast for the county and sub-county levels.



Global to National Data flows (thin lines) and value-added information flows (thick lines) into and through the entities and functions required for generating and delivering climate services. (source Richard Graham et al 2015)



Two-way flows of weather and climate information to support community resilience (Visman and Carpenter 2012**)**



Proposed two way flow of decentralised climate information and seasonal forecast distribution (Adopted from GOK-KMD, 2015 a**)**

Education and training including research and development are additional functions designated by WMO to KMD. Institute Meteorological Training and Research (IMTR) a branch of the KMD and is one of the twenty three the WMO-Regional Meteorological Training Centre (RMTC) in the world. IMTR is responsible in training personnel in meteorology, hydrology, and related geo-sciences in the country and in the Anglophone countries in Africa. The IMTR / WMO-RMTC has two components: the IMTR located at the KMD; and the University of Nairobi college of Biological and Physical Sciences, Department of Meteorology. These two components work together in coordination of training on matters pertaining to meteorology including application, education, training, research and development. Training and research in various components of climate information services is also provided by other collaborating stakeholders such as regional institutions such as ICPAC, and climate intermediaries.

4.1 Climate observations, data and analysis

4.2.1 Sources of climate data:

Kenya Meteorological Department (KMD) is the institution that is mandated to collect and store climate data in Kenya. Data collection is undertaken through the climate observing stations operated by the institution and also through collaboration with other institutions and volunteer observers. The World Meteorological Organization (WMO) is the institution that is mandated to develop the framework for this international cooperation and to create enabling environment for its implementation. The data exchange is achieved through the Global Telecommunication System (GTS). Kenya hosts the Regional Telecommunication Hub (RTH) responsible for data collection and exchange in eastern and Southern Africa. The major cause of non-availability of data from the region and country is the poor performances of telecommunication links. These limitations affect climate monitoring and prediction, not only for the country or region, but also for the entire global community. KMD through the decentralization plan has identified the need to expand its observation network in all of the counties and this will involve the enrolment of Community Climate Observers, and the application of Automatic Weather Stations, however these requires funding.

KMD operates thirty-six surface climate observing stations countrywide (called Synoptic Stations) which provide information on rainfall, minimum and maximum temperatures, wind speed and direction, air pressure, soil temperature, solar radiation, sunshine duration, relative humidity, evaporation and cloud cover. Over three thousand rainfall stations are registered by KMD and are operated by volunteer observers who mainly record rainfall data but some include temperature, however this number is still small as the optimum recommended number is ten thousand. Twenty four Automatic Weather Stations (AWSs) which automatically record climate data and transmit it to receiving stations at KMD. Most of these stations have long enough data that can be used for climate trend analysis, however care needs to be taken when using the volunteer stations as due to concerns of not adhering to recommended standards for observation.

KMD also operates three upper air stations located at Dagoretti Corner, Garissa and Lodwar. Of these only Dagoretti is currently operational and is making one ascent instead of two ascents per day as required due to inadequate resources for purchasing consumables. Four marine tidal gauges with automatic Meteorological sensors, which monitor ocean tides and waves as well as tsunamis are available. The data collected can be used to study sea level rise associated with global warming. This data is crucial in providing information to support decision making in adaptation planning for coastal zone management. Three Airport Weather Observing Systems (AWOSs) at Jomo Kenyatta International Airport, Wilson airport and Mombasa International Airport. These systems are able to detect and monitor hazards associated with extreme weather events. Four lightning and thunderstorm detection systems at Nairobi, Mombasa, Kisumu and Eldoret. These systems are used to provide severe weather warnings especially for aviation safety.

Data on water and river gauge are mainly obtained from the Ministry of Water and Irrigation or Water Resources Management Authority (WRMA) which is the institution that is responsible for maintaining and operating flow gauging stations. In total there are four hundred and fifty five river gauging stations operated by WRMA well distributed in the five drainage basins. In addition KMD recently installed seventeen hydro-meteorological automatic weather stations in the major water catchments for measurements of surface discharge and weather parameters. Monitoring of river discharge characteristics enables us to assess the impacts of climate on the water resources, planning in the water sector, especially discharge data used for monitoring of hydro-power generation. There are long periods of observations available in many of the hydrological.

In collaboration with such institutions as the Kenya Agricultural and Livestock Research Organization (KALRO) fourteen Agro-meteorological stations have been installed at the stations. These have daily recording of normal meteorological parameters conveyed to the Agro-meteorological division at the KMD headquarters, Dagoretti Corner, after every ten days for analysis and generation of advisory bulletins for the farming community. The agro-meteorology observations include: Air Temperature; Soil Temperature at five, ten, twenty, thirty, fifty and one hundred centimetre; depths; Sunshine duration; Radiation; Wind Speed; Relative Humidity; Pan Evaporation; and Rainfall in millimetres per day. In addition crop data is also obtained from the agro-meteorological stations, and these include: Variety of the grown crop; Stage of development attained by the crop; General assessment of crop performance; Damage by pests, diseases and adverse weather; State of weeding in the farm; and Plant density. This data and complimentary information is used to undertake assessment of crop performance under different climate conditions and to predict seasonal yields of the various crops and hence to assess food security. The information on the assessment is disseminated to the public through Agro-meteorological Bulletins which are published every ten days for early warning.

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. Much of the socio-economic information is obtained from other partners including government ministries and agencies such as KALRO, NDMA, KWS, KFS, KBS, DRSRS, WRMA, KFS, NEMA; from research institutions; and from international and regional agencies (FAO, US-FEWSNET). These includes information on wildlife and livestock population, surface water variability, crop performance, land use and land use change, forest cover, urbanization and human settlements, economic variables.

Satellite data are available and accessible from three satellite receiving stations, two for Meteo-Sat. Second Generation (MSG) and one for National Oceanic and Atmospheric Administration (NOAA) satellites data and also from the Regional Center for Mapping (RCMRD) and Department of Resources Survey and Remote Sensing (DRSRS). These stations receive global data on large scale systems such as sea surface temperatures and wind fields in cooperation with other international climate centers. The satellite data help in observing systems that drive the local climate systems such as global sea surface temperature fields. The satellite data is provided through the use of global observing satellites that transmit the data to the global climate centers which in turn process and transmit the same to the national climate centers. This data is crucial for predicting seasonal rainfall performance with sufficient lead time for early warning and preparedness. It is therefore a key component of contingency adaptation planning. Part of satellite derived information include the Normalized Vegetation Index (NDVI), rainfall derived information, cloud information, atmospheric profile, temperature and humidity profiles. These datasets helps in improving coverage and also in estimating and filling gaps in data scares areas and some of the satellite data and derivative products can downloaded from online data repositories. However the downside is usually the lack of insufficient skills required to use and apply them and the limited technical capacity of the user institutions needed to handle the data.

4.2 Modelling Climate information and data

The section describes the existing climate models and the different results in the target countries. It goes further to look at projections through the simulation of possible climate future in terms of temperature, precipitation, and other climate variables in the country.

4.2.1 Downscaling

Kenya Meteorological Department runs a Numerical Weather Prediction Model for generation of short term forecast. The outputs of which are applied in the generation of climate advisories and reviews. However considering the computing needs and the technical capacity required to conduct long term climate modelling for climate change scenario generation, has caused a reliance on information from Global Producing centres. Currently there are several available modelling centres around the world running various models and downscaling of model information, the most widely used in the country include the WMO global producing centres Global Circulation Models (GCMS); the Coupled Model Inter-comparison Project (CMIP) under the World Climate Research Programme (WRCP) who deal with atmosphere-Ocean General Circulation Models; and the Coordinated Regional Climate Downscaling Experiment (CORDEX) also under the WCRP. Much of these data can be found on online repositories and also with through ICPAC repositories.

Apart from the technical challenges in terms of computing and skills for use of climate models in the country, the difficulties in the application of climate models also comes from the issues of uncertainty. There are Natural uncertainty, which are related to the climate variability resulting from natural processes in the climate system; Human uncertainty, which Future emissions of greenhouse gases resulting from human activity (this becomes a larger component of uncertainty on time scales of 50 years or more); and Scientific uncertainty, an incomplete ability of the model capacity of computer systems and limited understanding to model Earth's complex processes.

The CIS producer use variety of tools, and a variety of processing depending on the required output to yield sector-specific information. Some employ expert consultation, consult with stakeholders, focused discussion groups, and use modelling. Participatory approaches involving focus group discussion, stakeholder, and expert consultations are the most preferred methods. The country has no framework for the evaluation of quality of data used by providers and the CIS derived from the data. Another challenge is the lack of standard procedures and availability of documentation for the methods used in generation of CIS product and services by most CIS providers. This reduces the validity and acceptability of product by the users and also makes it hard to ascertain the quality and probable value of the information used for decision making.

4.3 Stakeholders, users and decision-makers

The field of climate information in Kenya has attracted a vast array of participators, some are CIS producers, some intermediaries, and others are end users. However the chain of information flow links all and considering the importance of user feedback for improvement of CIS quality, the concept of end user become rather obscure. A study conducted by the World Bank in 2016 (WBG, 2016) on climate service providers in Kenya indicated that the climate service providers came from various association. 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. Some of the service providers also double as producers of climate information. Therefore it is good to note that CIS providers include Government, Non-Governmental Organizations, Private Sector players, Research institutions, farmers organisations and SACCOs, media, religious organization, county government, regional and international bodies, and UN organizations.

4.4 Relevant Legislation/Policies on climate information and services

Current Government of Kenya policies, plans, strategies and initiatives that provide a supportive framework for implementing information system include:

The Constitution of Kenya (2010) which provides ground for the formulation of adaptation and mitigation legislation, policies and strategies by guaranteeing the right to a clean and healthy environment under the Bill of Rights and also offers the opportunity for services to be moved closer to the citizens at the county and sub-county (constituency) or community/grassroots levels. This opportunity, in turn, calls for a concerted effort by KMD to strengthen its infrastructure and services to reach and have the desired influence upon the community or grassroots level of society, where the most severe impacts of climate variability and climate change are realized.

Vision 2030, the national development blue print encapsulates flagship programmes and projects with aspects of adaptation and mitigation. This include: provides for transport solutions that have relevance to climate change mitigation, and recognition of development through improvement of climate sensitive sectors.

The National Policy for the Sustainable Development of Northern Kenya and other Arid Lands focuses on climate resilience requiring Government to find solutions to address climate challenges and to come up with measures to manage drought and strengthen livelihoods. The policy also focuses on an enabling environment for accelerated investments in “foundations” to reduce poverty and build resilience and growth. The establishment of the National Drought Management Authority (NDMA), the National Disaster Contingency Fund and the Council for Pastoralists education are provided for in the policy.

The National Disaster Management Policy, 2012 institutionalizes disaster management and mainstreams disaster risk reduction in the country’s development initiatives. The policy aims to increase and sustain resilience of vulnerable communities to hazards. It also recognizes the impact of climate hazard and the need for building resilience through climate information.

Climate change act, 2016: provide legal framework for coordination and implementation of climate change issues including public participation.

National climate change response strategy (NCCRS) 2010 and the National Climate Change Action Plan (NCCAP) 2013-2017: promotes adaptation plans which "Contribute to development of climate information sharing and knowledge management systems; strengthen collaboration between MoA, KMD and others; and enhance capacity for agro-meteorological information provision and ensure effective service delivery mechanisms including climate smart extension."

Environmental Management and Coordination Act (EMCA, 1999): The Act is the principle instrument of Government for the management of the environment and provides for the relevant institutional framework for the coordination of environment management including the establishment of the National Environment Management Authority (NEMA) which is the Designated National Authority (DNA) for Clean Development Mechanism (CDM) and the National Implementing Entity (NIE) for the Adaptation Fund.

Water Act, 2002: The EMCA 1999 and the Water Act of 2002 provide the overall governance of the Water Sector. The regulations and strategies following on from this Act, recognize the climate change implications on health, sanitation and water.

The Energy Policy and Act: Kenya's energy policy of 2004 encourages implementation of indigenous renewable energy sources to enhance the country's electricity supply capacity. The policy is implemented through the Energy Act of 2006, which provides for mitigation of climate change, through energy efficiency and promotion of renewable energy.

The Agricultural Sector Development Strategy 2010-2020 is the overall national policy document for the agricultural sector. The strategy promotes sustainable food production and agroforestry. There are also broad implications for the forestry sector that are detailed in one of the six sub-sectors of the agriculture sector.

The Kenya Forestry Master Plan 1995-2020 provides for an overarching framework for forestry development in the country for the 25 year period up to 2020 and was the blue print for reforms in the sector, including the Forest Act of 2005 and Forest Policy of 2007. It recognizes the environmental role of forests including water values, biodiversity values, climate change values through carbon sequestration and other environmental services.

The Second National Environment Action Plan (NEAP, 2009-2013) provides for a broad framework for the coordination of environmental activities by the private sector and Government to guide the course of development activities, with a view to integrating environment and development for better management of resources.

5. Climate Information Needs

5.1 Sector-based assessments

In order to make climate-smart decisions activities, smallholder farmers, pastoralists, fishers, and institutional users such as government, extension offices and local NGOs, require weather and climate services which are seamless across timescales ranging from daily to seasonal outlooks and beyond. However, the provision of this information is not enough to ensure its effective use in decision-making activities. In order to be successfully implemented, weather and climate services need to address the following five criteria: relevance (or salience), easily accessible and understood, co-designed with user input, inclusive of marginalised groups, and broadly integrated in cross-sectoral frameworks and national development plans. Through meeting these criteria, and taking an integrated approach to designing, producing, communication and evaluation, effective weather and climate services are possible, but not without challenges (Tall et al., 2014).The increased public interest in and the need for climate and weather information across sectors has create a dynamic CIS field in Kenya, with varying information needs targeted to different sectors and users. Thus, the CIS providers serve a diverse community of users with sector-specific climate Information. The sectors of interest within the country for CIS providers are agricultural and livestock, water and water resources, financial/planning, environmental and natural resources, energy, research and development, health, media, construction/infrastructure, disaster management (WBG 2016)

5.1.1 Agriculture, livestock and food security

It has been evidently been shown that Food security, pastoralism, agricultural productivity and marine fisheries are sensitive to weather and climate variability. These forms the keys sectors of concern for majority of CIS providers in the country. Agricultural users of weather and climate services in typically require weather and climate products on a combination of timescales, including historical observations, monitored information throughout a growing season, daily/weekly weather forecasts, monthly outlooks, seasonal predictions, and decadal climate change projections (Tall et al., 2014). Some of the agro-climatic advisories available in the country include: Planting window/varieties selection, land preparation, harvest, postharvest, input application rate, timing of input application, input stocking, input procurement, financing arrangement, and market information (WBG 2016)

Currently much of the climate information is provided for at 10 day, monthly and seasonal scale by KMD and usually at the national level. However there has been some initiatives to improve the uptake of CIS information at the local scale these include: the decentralization of climate services to the county level; Christian Aid SALI project promoting enhanced community engagement in the uptake of CS through the co-development of community-based adaptation strategies through appropriate, 'localized' interpretation of weather and climate products from NMSs (Christian Aid, 2011; Christian Aid, 2012); the Adaptation Learning Programme (ALP) for Africa by CARE, that develops community-based risk-management strategies, involving participatory engagement of rural communities to assist with designing agricultural advisories based on probabilistic seasonal forecast information from NMSs (CARE ALP Brochure, 2011). Some tools are being employed in downscaling of climate information to the local level such as 'FIT Interpretation Tool' (Brown, 2008), developed by the Famine Early Warning Systems Network (FEWSNET – associated with USGS and USAID).

Already the country has an established a consortium of several stakeholders through the Kenya Food Security Committee and the technical component of Kenya Food Security Working Group who are concerned with issuance of advisories and briefs on the food security situation. Some of the identified gaps and needs for the climate service in the country include: Strengthening of Regional, national and subnational Climate Outlook Forums and integration with wider government frameworks and plans (WMO, 2014b); Further development of tools for downscaling of climate information to produce local information and forecasts (Brown, 2008); Further research into how local indigenous knowledge can be combined with climate services and support climate information (Masinde, 2014); Scaling up of successful climate services projects in the food security sector, which address the key criteria identified in recent studies (e.g. Tall et al., 2014); Developing tailored forecasts to meet user needs, including the use of local languages and a wide range of communication channels (Tall et al., 2014; Lumbroso et al., 2014); Provision of simple weather and hydrological monitoring equipment to local communities to raise awareness, promote dialogue and data exchange

5.1.2 Water resources

Kenya is generally referred as "water scarce country". Information needs for water sector involve water planning for industrial and domestic use including surface and underground water, and also issues that relate to drought and floods risk management. Drought affect water availability within the country, and many urban areas in the country are already facing water shortage, with Increasing urbanization of semiarid and dry lands, there is serious competition for the available water..

Kenya has already made much efforts in the development of integrated water resource management, with information on flood and drought early warning being provided by KMD. Water Resource Management Authority (WRMA), working with KMD and other stakeholders they generate water supply information, especially for key water areas such as urban water and hydropower generation. However there is still a limitation in the use of tools that enable real-time monitoring of basing flow and provision of decision-making tools that are accessible to some local users. The supply of the information required for IWRM implementation in parts of the country is a major challenge owing to poorly developed and/or the deteriorating state of climate services. (World Water Council, 2003; Kadi et al., 2006; Adeaga, 2007; ClimDev-Africa, 2013) many decisions ranging from policies to design of infrastructure are based on unreliable information which can result in the unsustainable management of water resources.

Improving water management through the use of climate services, will require identifying relevant climate services which include climate predictions products, seasonal climate, outlooks, downscaling products at various levels and different downscaling methodologies. Flood risk assessment requires information of peak flood flows for infrastructure design and floodplain mapping as well as flood forecasting and warning services. Climate information needs to be combined with vulnerability data for many applications. For drought risk management there are similar requirements for design and operational climate services. For water resources management climate and hydrological data are required to estimate resource potential, sustainable yields and allocation of resources through licensing or permitting at the catchment scale.

Application of climate information for Integrated Water Resource Management (IWRM) will require: a stronger enabling environment to support capacity building and international, regional and national collaboration in water management; building national capacity in national hydro-meteorological services from data observation and retrieval through application of necessary tools that allows easy access of information by users; improving the hydro-meteorological monitoring network and data management and improving the collection and exchange of climate data including IT infrastructure to support remote access to data; Enhancing application of satellite observation data and application of modern technology.

5.1.3 Health

Weather and climate conditions on all timescales have both direct and indirect effects on public health and safety through extreme events such as heat waves, floods and droughts, as well as the prevalence and severity of infectious, vector- and water-borne diseases such as meningitis, malaria, and diarrhoea (WMO, 2014a) and cholera (de Magny et al., 2007). Rapid urbanisation with a lack of modern drainage systems and wastewater systems has the potential for increasing the prevalence of water-borne diseases. While the impacts of weather and climate on public health are widely recognised, the uptake and implementation of climate services to inform policy and decision making activities within the health sector is relatively low (Jancloes et al., 2014; WMO, 2014a).This could be attributed to factors such as: limited capacity to effectively use and understand climate services; the apparent inability to manage and monitor the risks of climate variability and change on public health; lack of access to the relevant datasets, and an institutional disconnect between the public health community and other sectors which consider public health as a downstream priority such as food security and water resource management (Jancloes et al. 2014; WMO 2014a).

Kenya has already developed national level partnerships through the implementation of Climate and Health Working Groups (CHWGs), which has established strong national partnerships between the climate and health communities for the conduct of research, education and data exchange (Rogers et al., 2010). Key outcomes of the CHWGs has been improved service delivery and increased capacity of NMSs, through a sustained partnerships, increasing cross-sectorial collaboration. There is still a limitation in the development of decision-support tools that is relevant to the health sector, and the cooperative development of weather and climate advisory services for practical use in the health community (Connor et al., 2010).

Ways to improve the effective integration of climate services into the decision-making in the health sector include: promoting two-way dialogue channels and strengthened partnerships between CS providers and the health community; investing in human resource and institutional capacity development activities while promoting interdisciplinary research into the potential effects of climate variability and change on public health; and improving the access, understanding and relevancy of both climate monitoring and health surveillance datasets (Connor et al., 2010; Clim-Health Africa, 2013; Jancloes et al., 2014;WMO, 2014a)

5.1.4 Energy

About 60% of electric energy that is generated in the country is from hydro-power dams in the major rivers. The country has been experiencing power shortages associated with the recurrent droughts. The risk of serious power shortages and resultant slowing down of economic growth will be even higher as droughts increase in frequency and intensity. KENGEN is the organization mandate to see the generation of electricity in Kenya. KENGEN has collaborated with KMD to apply use of climate knowledge especially for energy planning at seasonal and for long-term implementations in the hydroelectric power plants, climate information has also been useful in the planning of wind and solar energy plants. However lack of such datasets as wind and solar energy, create a challenge in application of such green sources of energy. However the potential of application of satellite energy for such information is viable and these needs to be tested and applied.

The application of green energy for climate mitigation and the need for planning of energy generation will continue to require climate information, especially on hydrological fluctuations, wind, and solar viability, and also on risk such as storm and lightening surges.

5.1.5 Disaster management

The country is faced by a variety of climate related hazards the key ones being drought and floods. There is awareness on the need for a coordinated disaster risk management framework. Climate information is required to increase resilience to climate related disaster, and KMD and partners established through the Kenya National Disaster Response Plan, work together. KMD is in the process of implementing Common Alert Protocol (CAP) which provides public alerts for all kind of hazards, including unusual and extreme weather events, power cuts, health, agriculture and food security, and other emergencies.

However challenges are still present in capacity and technical needs on developing some of the information but more in the communication and transmission of the alerts, especially to local users. Moving foreword requires the application of tools especially ICT based platforms in the generation, downscaling and communication of early warning information.

	Sector	**Existing situation**	**Specific needs/gaps**
a)	Agriculture and food security	Provision of climate information for agriculture including onset, cessation rainfall distribution, produced at seasonal and update on 10 day basis Kenya Food Security Committee and the technical component of Kenya Food Security Working Group has been established It is the sector with most stakeholders concern for CIS providers. Use of agriculture extension officers in some places but based on request basis Awareness of climate-livestock related diseases, and application of measures such as vaccination in risk zones during some seasons Promotion of smart agriculture	Integrated information for agro-climatic information provision Not all crops and regions are served Should include pest and diseases monitoring
b)	Health	Awareness of the association climate and vector related diseases such as malaria and also on water related diseases such as diarrhoea Seasonal contingency measure provided for malaria	Information on temperature related heat stress are not available, ie no platform for regular update for health risk Much of the information are limited to the national scale and at

		Limited availability of health information for research on climate relate health risk Existence of national Climate Health Working Group Climate health advisories provided mainly at the national level	seasonal level not at a local scope Improve partnership between climate information producers and health information sector Platform for availing of health data and also facilitating research on climate related health risk Identify local climate risk for related to health
c)	Energy	Awareness of the impact of climate variability on energy generation Seasonal and continual monthly contingency planning for river flow and dams for energy production is available Long-term assessment of energy potential is available but limited especially looking at green energy sources such as wind, and solar Limited access to data on energy consumption and needs	Information on alternative green energy potential such as solar radiation potential and Wind energy potential Improve monitoring and research of climate aspects for application of green energy sources Technical capacity for assessment of energy audits and variation with climate change especially for cooling days and warming days
d)	Water resources	Information on river discharge, ground water mapping, Reservoir monitoring for urban water supply is available. Seasonal contingency planning based on seasonal forecast Modelling of water is limited	Some stations have data gaps due to lack of volunteer observers Information of ground water availability and recharge is not comprehensive Increase capacity for water modelling, and integrated water information service Limited platform for access of water resource information, weakness in enforcement of water Lack of platform for access of information on potential for water harvesting
e)	Disaster management	Recognition of the risk of climate related disasters Establishment of multiagency framework for coordination of disaster management. KMD in the process of implementation of CAP although challenges is in the translation of information and dissemination especially	Need for decision support tools for ease of collaboration of participating agencies Improve on the dissemination of CIS early warning especially using modern ICT technology

6. Availability of climate information in target country

KMD currently provide a range of climate information both at short, medium, long range, seasonal and sub-seasonal scales. At the national level daily, 3 days, 5 days 7 day, 10day, monthly and seasonal weather forecasting and review are available for the general public. The public weather climate information are offered without charge and can be retrieved from the KMD website, and are also posted on KMD social media handles and through email request.

Unusual and extreme weather events: Together with the NDMA, WMO and Red Cross, KMD has been working on an integrated solution of Alerts/Warning production & dissemination and has commenced the adoption of the Common Alert Protocol (CAP) which provides public alerts for all kind of hazards, including unusual and extreme weather events, power cuts, health, agriculture and food security, and other emergencies, and works through all media, including cell phones, radio, and other internet based networks. Currently generating warnings and advisories on heavy rains and storms, strong winds, marine advisories, temperature, and Tsunami & Seismic advisory (GOK-KMD, 2015).

Daily Forecast: are issued and includes: rainfall intensity, humidity and geographic location(s), reported rainfall amount, unusual weather-related events
Five-day forecast: Forecast for next 5 days are issued, including rainfall location and intensity, temperature, cloud cover, fog, strong winds, advice on daily rate for irrigation
Ten-day forecast: Agro-meteorological bulletins issued every ten days to provide information on assessment of crop performance and expected climate conditions that may affect the crops.
Monthly Forecast: Issued for the next month on rainfall location and intensity, temperature, extreme weather events.
Seasonal Forecast: Provided for the major rainfall seasons, includes Seasonal Onset, quality, distribution, cessation of rains, extended dry spells, Livelihood advisories developed with NDMA and Ministries of Agriculture and Livestock, and Ministry of Water and Irrigation, and Energy. The forecasts also contain warnings on expected climate related hazards including areas likely to be at risk and advisories on cautionary measures that should be taken. These seasonal forecasts are issued in good time for early warning for communities and institutions for preparedness and contingency adaptation planning.

Longer-term: Longer-term trends in climate, variability and change employing historical data and climate models, combining parameters relevant to specific sectoral decision-making. These are done through special releases such as policy brief documents.

Information for civil and military aviation and marine transport are also provided based on the recommended standards forecast. Information on marine conditions include general state of the ocean such as wave heights, wind speeds, visibility, and ocean currents. This information is provided to the communities in the proximity of the oceans, ships and fishermen.

The public information expected to be replicated and downscaled by the county level at the local scales and for the local needs. Most of the county offices currently downscale the seasonal climate information and the early warning advisories only. This can be attributed to limitation in human capacity, and technology to seamless downscaling, dissemination and access at the county and sub-county level

7. Linking Socio-economic data to climate information:

In order to provide climate information that is effective, it has to be user centred and focus on addressing the user needs. This requires not only climate information but other socio-economic and livelihood information. Much of the socio-economic information is obtained from other government agencies such as NDMA, WARMA, NEMA, KFS, KWS, KBS and from government ministries; regional and international organization such as FAO, US-FEWSNET, UN organizations; and research institutions such as universities. The climate change initiatives in the country highlights the importance of climate information for development and the adaptation and mitigation actions as well as the vulnerability assessment highly depends on an array of information from both the climate and other sectors. Streamlining climate information into people centred development will further increase resilience.

7.1 Livelihood systems and livelihood assets

The country's economy is highly dependent on climate sensitive sectors including agriculture, tourism, and energy. Agriculture is the backbone of the Kenyan economy directly contributing 24% of the GDP in 2009 and another 27% indirectly. The sector accounts for 65% of informal employment in rural areas. Kenya faces major food security challenges due to the over dependence on rain-fed agriculture for food production. The number of Kenyans requiring food assistance rose from 650,000 in 2007 to almost 3.8 million in 2009/2010. Pastoral and marginal agricultural areas are particularly vulnerable to the impacts of climate change. Extended periods of drought erode livelihood

7.2 Local perception of risks associated with lack of climate information

Much of the information for a while has been produced at a national scale, which is not applicable for the local users making the users feel that the information was general as it sometimes did not reflect the actual variability at the ground level. The information is also sometimes in a form that is not well understood by the end users and requires extra knowledge to interpret, such as probabilistic information. These factor are compounded by the situation where climate information climate information is not involving and does not evolve around the user, creates a situation of increased mistrust by the users. However with decentralization there is increased awareness of the availability and of CIS information and also on the engagement of end users in the generation of information, and these have seen more and more users use and accept climate information.

7.3 Indigenous knowledge of practices and strategies

In several areas especially where CIS is not available users depend on the indigenous practices for application. The challenge has however risen due to climate change and factors such as reduction of soil fertility, and hence in some places the continued dependency on indigenous practices along leads to reduced productivity. Studies have shown that the existence of indigenous knowledge if well improved and supported by CIS increases productivity abundantly. It also creates a structure for easy adoption of climate information services.

7.4 Extreme climatic events and impact on population and economy

The country disaster profile shows that over seventy percent of disasters are climate related, caused by extreme climate events. Much of the country is affected by frequent climate extremes the major culprit is drought. Drought has been shown to create losses that run into billions of dollars and also lead to loss of lives and livelihoods. Extreme rainfall and Floods, extreme temperatures, and strong winds are also other extreme climate situations that are very devastating. Extreme rainfall and winds are also known to lead to loss of lives and property.

7.5 Current vulnerabilities

7.5.1 Exposure

The rainfall of the country vary very much in space and time, most of the areas receive bimodal kind of rainfall which some receive unimodal kind of rainfall. Rainfall distribution amounts also varies in different regions with the higher altitude areas recording more amounts, however local variation still occurs, Temperature is also much varying with the months of June to August recording the lowest temperature in most parts. There are frequent occurrences of extreme weather conditions such as droughts and dry spells, high winds, extreme rainfall, and floods and even landslides. Droughts and floods affect the highest number of people and with increasing population, the number of affected people are also rising. Such as the 1995/6 affected 1.41 million, 1999/2000 affected 4.4 million and 2004-2006 affected 11 million (GOK 2006b). The 1997/98 floods, on the other hand, are estimated to have affected about 1 million people, costing the economy US$0.8-1.2 billion in terms of damage to infrastructure (roads, buildings and communication systems), public health effects and loss of crops. Other losses amounting to US$9 million arose from flooding, property destruction, soil erosion, mudslides and landslides, surface and groundwater pollution and sedimentation of dams and water reservoirs

There has been observed a general increasing trend in temperature in most parts of the country. Rainfall trends show mixed signals with some locations indicating trends towards wetter conditions in recent years, but the majority of locations are not showing any significant trends. The annual rainfall shows either neutral or slightly decreasing trends due to a general decline in the long rains season that extends from March to May. The short rains season between October and December, on the other hand, shows a positive trend in some locations (GOK 2010).

7.5.2 Sensitivity

Much of the economy and livelihoods of much of the population is sensitive to climate variability withe nearly 80% of the country being covered by arid and semiarid land, and around only 7.8% being arable land. Much of the agricultural practice which supports the economy and act as basis for food security is rain-fed, with two rainfall seasons from March to May and October to December, with some areas experiencing a single growth period from June to December. The country is generally categorised as water scarce. The energy sector has largely depended on hydro-power which contributes about 50% of the total national energy production. The tourism sector that relies on wildlife has also experienced huge impacts due to droughts and variability.

7.5.3 Adaptive Capacity

According to the Kenya Climate Change Action Plan 2013-2017 (GOK 2013b), the Government and other stakeholders are implementing many interventions that have direct and/or indirect relevance to climate change adaptation and mitigation. The interventions cover a wide range of sectors including: agriculture, water, energy and infrastructure. These include:

Agriculture: promoting irrigated agriculture, promoting conservation agriculture, value addition to agricultural products, developing weather indexed crop insurance schemes, support for community-based adaptation including provision of climate information to farmers, enhanced financial and technical support to drought resistant crops.

Livestock and Pastoralism: Breeding animals tolerant to local climatic conditions, weather indexed livestock insurance, establishment of fodder banks, documenting indigenous knowledge, provision of water for livestock and humans, early warning systems for droughts and floods, and vaccination campaigns.

Water Resources: Enforcement and/or enactment of laws for efficient water resource management, increasing capture and retention of rainwater, water quality monitoring, de-silting rivers and dams, protecting and conserving water catchment areas, investing in decentralized municipal water recycling facilities, campaigns on water harvesting, developing hydrometric network to monitor river flows and flood warning.

Forestry: Intensified afforestation, promoting agroforestry-based alternative livelihood systems, promoting alternative energy sources, community forest management, REDD+ initiatives and reduced mono-species plantation stands.

Energy: promoting the use of alternative energy including geothermal, wind, solar and mini hydro power generation; and the promotion of improved cook stoves.

	Socio-economic Aspects	**Existing situation**	**Specific needs/gaps**
a)	Livelihood systems	Reliance of climate sensitive livelihood systems such as rain-fed agriculture, livestock, tourism, and energy Awareness of the influence of climate on livelihood systems	-Lack of climate information for adaptation especially at the local level Limited technical capacity for mainstreaming climate information to development initiative
b)	Local Perceptions	Much of the climate information is generally not understood or in the right format Lack of trust on the climate information	Interpretation of CIS information Outreach and awareness of use and application of CIS Participatory approach in the application of CIS
c)	Indigenous knowledge and practice	High dependency on indigenous knowledge especially in places with no	Integration and improvement of indigenous knowledge into the CIS provision

		access to CIS Highly susceptible to climate change and causes reduction in productivity	

8. Constraints on the collection, analysis and usability of climate and weather information

Lack of sophisticated climate tools

The technical and computing facilities and also lack of good network of data hinder the application of some tools which would improve climate information generation. Climate tools are also not available for local scales and especially for climate downscaling purposes. Some of the technology including satellite based systems are in limited use by CIS providers, due to lack of technical capacity to apply them. Limitation in financing has also contributed to the low pace of adoption of technology and necessary tools especially integrated climate information system.

Quality

There are many players in the CIS environment in Kenya, providing various climate information services and products. The skill score for KMD forecast for now-casting (one hour-6 hours) to medum range (1 week) is greater than 85%, while for long range (monthly to seasonal) is between 70 and 85% (GOK-KMD 2014a). There is still no legal and common framework for sharing of CIS information or procedures of operation, which directly defining the generation of user oriented climate information products. Most CIS providers have no feedback structure and also a review and a documentation for the processes of the generation of their products. These hinders the process of review of the climate products and services products so as to define and justify quality. The CIS field in Kenya is also not fully coordinated however various service producers work together and especially with KMD and end user to co-produce products.

Appropriateness of scale

Different climate users have different information needs and these varies in temporal, spatial and even in form. The efforts to decentralise climate information to the county level, has open up the field for diverse demand for climate services that are appropriate for user level decisions making. Although the national level products are expected to be downscaled to the county level, the different local levels creates demands for unique products some which needs to be regenerated at the local scale. There are lack of tools to support such downscaling and the procedures are also not well developed and documented. There should be a system and tools that can enable downscaling of climate information at the local levels and also generating and retrieval of climate information at the local level to promote user required information.

Communication

The diversity of user needs in the country, and also the difference in culture and language, literacy level are key challenges in the development and communication of climate information. These are compounded by lack of the right technology which allow for equal access to information to all who need it. Most climate information come in a form that might not be readily applied for user level decision making either because they are technical or the method of dissemination become a challenge hindering accessibility and applicability.

Interpretation

The application of climate information needs an understanding of both the technical aspect of the information and the applicative needs of the users. This require the effort of interpreters who understand the technical aspect of the content of the climate information and can also the user applicative needs. However this is usually not the case, mainly because some of the CIS come in technical language, or may not be have the right content or form recommended for applicability. There is also the challenge of translation which considering that there is ethnical diversity in the local climate users in Kenya, and this has been one of the great challenges in developing content especially for some media being applied such as RANET, and SMS and bulletin.

Lack of manpower

Most county offices run way below the recommended number of workforce, and because the provision of CIS require some level of understanding of processes and concepts and also because of the diverse needs of the climate users at the local grounds, the human resources cannot be enough to cover all users. Even with the inclusion of various agencies and stakeholders in the CIS field in Kenya, the demand for workers has not been met. The challenges also in the lack of tools to assist in the processes necessary for achieving an integrated climate information system.

9. Opportunities and Ways Forward

In order to improve CIS deliver in the country it is recommended to:

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, this include the implementation of appropriate business model and operation model and promote public private partnerships.

With the changing demands caused by climate change and the opportunities that arise from it is important to enhance the capacity of the staff to be able to support such needs, and also employ various ways to avail enough human resources such as community climate observers and train them so as to increase the capacity to tackle the demand for appropriate climate services. Support should be given to establish, rehabilitate and upgrade and equip meteorological, and hydrological network so as to have enough coverage that will enable for better data for climate service provision such as downscaling of information.

There is need to increase capacity to use satellite products and also the need for strengthening capacity in climate modelling, application of modern monitoring technology including maintenance of equipment, quality control of data and calibration of the facilities. The capacity to apply ICT technology and all possible avenues in communication and transmission and dissemination of climate information should be improved, this should focus on provision of user interface that can allow for feedback process and encourage interaction between stakeholders. Efforts should be put in place to support further research on climate information and application especially in generation of climate input and in the understanding of climate systems including climate change issues.

Improve coordination of CIS provision: 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, and user specific products. The strategy should define a proper coordination mechanism for the various ongoing CIS processes. The platform can include a web-based information portal for climate service providers, service and product portfolios including methods of generation, and encourage of continuous interaction of various stakeholders and user. 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..

A formal framework that will allow networking of CIS providers and key stakeholders, and provision of standard operation procedures for products generation and dissemination. An approach to protect data ownership and equally eliminate barriers for effective exploitation of climate information is needed.

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, labelling, and validation is required. There should be put in place standard procedures for evaluating climate data and products and also offer. Encouragement of establishment of effective and interactive user feedback mechanism can also provide avenue for evaluation and improvement of climate information products and services

Foster partnerships of CIS: There is greater need to collaborate in the production and generation of climate information products especially in co-designing of climate products with end users and providers, more gap in the provision of climate information can be bridged through such effort. 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 co-learning and co-management strategies involving providers and users should be encourage. Trans-disciplinary, multidisciplinary research to sup-port co-development 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.

There should also be creation of increased awareness on available climate information and also on potential and emerging climate information products and services.

Promote integrate CIS into ongoing initiative:

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 sec-tor 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.

Conclusion

From this review it is important to note that there are various stakeholders in the CIS environment in Kenya and the CIS field is very dynamic with various products and services being offered. Kenya Meteorological Department is the mandated institution for the provision and coordination of CIS. There are also numerous data sources that are a needed for climate information product generation, including climate and socio-economic and livelihood information. Climate are mainly obtained from KMD and also other agencies, private sector and also volunteer staions. The use of satellite derived datasets is also applied in the country by some CIS providers.

The government of Kenya is well aware of the consequences of climate change and the need for climate information. Climate change provides emerging challenges and opportunities for CIS provision which needs to be explored. There are various challenges caused by limited technical capacity, human resource needs, financial challenges, and general operation environment for CIS provision. These challenges hinder provision of climate information especially at the grassroots and level, considering the recently established decentralization initiative for establishment climate information to the county level by the KMD. These challenges should be overcome but most of all a framework for the collaboration and integration of CIS activities needs to be established so as to proper coordinate climate service within the country.

More opportunities for funding and provision of climate information as highlighted in the climate change action plans should be explored, considering improving technical capacity, infrastructure, communication, and also encouraging research and application of new technologies and tool in monitoring, analysis and modelling, and information dissemination. This will be beneficial in the bridging of gaps in climate change information provision for application for user decision level

Reference:

Adeaga, O. (2007) Constraints and prospects of hydrological science practices in sub Saharan Africa, in International Association of Hydrological Sciences, HW30094841 –4847, Workshop on loss of knowledge

AEA Group. (2008a). Final report. Kenya: Climate screening and information exchange (ED 05603, Issue 2). Retrieved from http://www.dewpoint.org.uk/Asset%20Library/DFID/Climate%20Risk%20Assessment%20Report%20-%20Kenya.pdf

African Union (2014): African Strategy on Climate Change. AMCEN-15-REF-11

Braimoh, Ademola & Ngari, Francis & Anyango Obuya, Grace & Hou, Xiaoyue & Larson, Gunnar. (2016). Climate Information Services Providers in Kenya.

Braimoh, A., I. Oladele, X. Hou, and G. Larson. 2015. "Increasing Agricultural Production and Resilience through Climate Information Services." Agriculture Global Practice Note 07. World Bank.

Brown, M., 2008. Chapter 18: The future of FEWS NET. Famine Early Warning Systems and Remote Sensing Data, pp 297-309, Springer Berlin Heidelberg.

CARE ALP Brochure (2011). Adaptation Learning Programme (ALP) for Africa. Available at http://www.careclimatechange.org/adaptation-initiatives/alp.

Christian Aid, 2011. Review of the Innovation Fund Projects on Climate Change Adaptation 2008-10. Available on UNFCCC website (http://unfccc.int/files/adaptation/application/pdf/christian_aid_review_of_the_innovation_fund_projects_on_climate_change_adaptation_2008-10_160811.pdf)

Christian Aid, 2012. Strengthening Access to Climate Information – the impact of the Sustainable Agricultural Livelihoods Innovation (SALI) project. Project report, available at http://www.christianaid.org.uk/whatwedo/africa/kenya.aspx?Page=3.

Clim-Health Africa, 2013. WMO Bulletin 62, Special Issue, pp 35-40.

ClimDev-Africa (2013) Africa's climate observing networks: Challenges, needs and recommendations.

Connor, S. J., Omumbo, J., Green, C., DaSilva, J., Mantilla, G., Delacollette, C., Hales, S., Rogers, D., Thomson, M., 2010. Health and Climate Needs, Procedia Environmental Sciences, 1, 27-36.

de Magny, Guégan, J.F.,Petit, M. and Cazelles, B. (2007). Regional-scale climate-variability synchrony of cholera epidemics in West Africa. BMC Infectious Diseases 2007, 7:20 doi:10.1186/1471-2334-7-20 http://www.biomedcentral.com/1471-2334/7/20

Dinku, T., et al. "The ENACTS approach: transforming climate services in Africa one country at a time." World Policy Papers (2016): 1-24.

Dinku, Tufa & Hailemariam, Kinfe & Grimes, David & Asefa, Kidane & Connor, Stephen. (2011). Improving Availability, Access and Use of Climate Information. WMO Bulletin. 60. 80-86.

Dinku, Tufa, Paul Block, Jessica Sharoff, Kinfe Hailemariam, Daniel Osgood, John del Corral, Rémi Cousin andMadeleine C Thomson. "Bridging critical gaps in climate services and applications in Africa." Earth Perspectives 1.1 (2014): 1.

Food and Agriculture Organization of United Nations: Climate change and food security: A framework document. Rome; 2008. Retrieved on 02.11.2017, from http://re.indiaenvironmentportal.org.in/files/climate-foodsecurity.pdf

Government of Kenya (GOK) (2010). National Climate Change Response Strategy, Executive Brief

Government of Kenya (GOK) (2012a): Kenya's National Climate Change Adaptation Plan, 2012.

Government of Kenya (GOK) (2006a). Disaster risk reduction strategy for Kenya 2006–2016: A resilient and safer nation. Unpublished.

Government of Kenya (GOK) (2006b): National Disaster Response Plan

Government of Kenya (GOK) (2007a). Kenya vision 2030: A globally competitive and prosperous Kenya. Retrieved from http://www.kilimo.go.ke/kilimo_docs/pdf/Kenya_VISION_2030-final.pdf

Government of Kenya (GOK) (2007b). Kenya vision 2030: The popular version. Nairobi: Government of Kenya. Retrieved from http://www.vision2030.go.ke/lib.php?f=vision-2030-popular-version

Government of Kenya (GOK) (2008). First medium term plan (2008–2012). Nairobi. Retrieved from http://www.imf.org/external/pubs/ft/scr/2010/cr10224.pdf

Government of Kenya (GOK) (2012b): Kenya's National Climate Change Adaptation Plan (NCCAP), Executive Summary,2012.

Government of Kenya (GOK) (2012c): Government of Kenya Adaptation Technical Analysis, Technical Report 8: Availability and Accessibility to Climate Data for Kenya.

Government of Kenya (GOK) (2013a). Second medium term plan (2013–2017). Retrieved from http://www.vision2030.go.ke/lib.php?f=second-medium-term-plan-2013-2017

Government of Kenya (GOK) (2013b): National Climate Change Action Plan (2013–2017). Ministry of Environment and Mineral Resources

Government of Kenya- Kenya Meteorological Department (GOK-KMD) (2014c): Development of Decentralized Climate Information Services in Kenya, Adaptation Consortium Climate Information Service Report: December 2014

Government of Kenya- Kenya Meteorological Department (GOK-KMD) (2014a): New Climate Information Services for Kitui. Retrieved on 01.11.2017 from http://www.adaconsortium.org/images/NEW-CLIMATE-INFORMATION-SERVICES-FOR-KITUI.pdf

Government of Kenya- Kenya Meteorological Service (GOK-KMD) (2016): Wajir County Climate Information Services Strategic Plan

Government of Kenya- Kenya Meteorological Service (GOK-KMD) (2015): Kitui County Climate Information Services Strategic Plan

International Research Institute for Climate and Society (2006): A Gap Analysis for the Implementation of the Global Climate Observing System Programme in Africa

International Research Institute for Climate and Society, 2006, A Gap Analysis for the Implementation of the Global Climate Observing System Programme in Africa, Columbia University Academic Commons, https://doi.org/10.7916/D8BK1K7J.

IPCC, 1996: Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change [Houghton., J.T., et al.(eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 572 pp.

IPCC, 1996: Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change [Houghton., J.T., et al.(eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 572 pp.

IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, Sl, D.Qin, M.Manning, Z. Chen, M.Marquis, K.B. Averyt, M.Tignor and H.L Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp

IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, Sl, D.Qin, M.Manning, Z. Chen, M.Marquis, K.B. Averyt, M.Tignor and H.L Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp

IPCC, 2012: Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564.

IPCC, 2012: Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564.

Jancloes, M., Thomson, M., Costa, M. M., Hewitt, C., Corvalan, C., Dinku, T., Lowe, R., Hayden, M., 2014. Climate Services to Improve Public Heath, International Journal of Environmental Research and Public Health, 11, 4555-4559.

Jo-Ellen Parry, Daniella Echeverria, Julie Dekens and Joseph Maitima (2012): Climate Risks, Vulnerability and Governance in Kenya: A review

Joseph Curry (2001): Use of Climate Information in the Greater Horn: Assessing the Needs of Institutional Users. International Research Institute for Climate Prediction.

Kadi, M., Njogu Njau, L. Mwikya, J. Kamga, A. (2006) The state of climate information services for agriculture and food security in East African countries, Working Paper No. 5, CGIAR Research program on climate change, Agriculture and Food Security (CCAFS)

Lumbroso, D., Rance, J., Pearce, G. and Wade, S. (2014) Science for Humanitarian Emergencies and Resilience (SHEAR) scoping study: Final report 14 March 2014, Evidence on Demand

Marina Apgar, Dominic Kniveton, Lars Otto Naess, Victor Orindi, Nicholas Abuya, and Mumina Bonaya, Emilie Wilson (Ed) (2017): Improving the Impact of Climate Information Services in Kenya's Arid and Semi-Arid Lands. Policy Briefing, ISSUE 145 OCTOBER 2017. Institute of Development Studies, Brighton BN1 9RE UK.

Masinde, M. (2014) An effective drought early warning system for sub-Saharan Africa: Integrating modern and indigenous approaches, in Proceedings of the Southern African Institute for Computer Scientist and Information Technologists Annual Conference 2014 on SAICSIT 2014 Empowered by Technology (SAICSIT 2014), J. P. van Deventer, M. C.

Odada E, Barange M, Goddard L. "Needs Assessment for Climate Information on Decadal Timescales and Longer." Procedia Environmental Sciences. 2010;VOLUME 1: Pages 275-286.

Rogers, D. P., and V. V. Tsirkunov. 2013. "Weather and Climate Resilience: Effective Preparedness through National Meteorological and Hydrological Services." World Bank.

Richard Graham, Emma Visman, Steven Wade, Rosanna Amato, Caroline Bain, Tamara Janes, Bill Leathes, and Darren Lumbroso, Emily Boyd, Ros Cornforth, and David Parker (2015): Scoping, Options Analysis and Design of a 'Climate Information and Services Programme' for Africa (CIASA): Literature Review. DOI:http://dx.doi.org/10.12774/eod_cr.may2015.grahamr

Sharma, V.; Orindi, V.; Hesse, C.; Pattison, J. and Anderson, S. (2014) 'Supporting Local Adaptation Planning and Implementation Through Local Governance and Decentralised Finance Provision', Development in Practice 24.4: 579–90

Tall, A., Hansen, J., Jay, A., Campbell, A., Kinyangi, J., and Zougmoré, R 2014. Scaling up climate services for farmers: Mission Possible. CGIAR Research Program on Climate Change (CCAFS), Report No. 13.

UNDP, WMO, GOK, IGAD, and DMCN, (May 2002), Factoring Weather and Climate Information and Products into Disaster Management Policy, A Contribution to Strategies for Disaster reduction in Kenya. Nairobi Kenya.

Visman and Carpenter 2012. A Proposed Framework for Systematic Use of Weather and Climate Information across Humanitarian, Disaster Risk Reduction and Development Communities, (2012). Workshop for the UK Government Office for Science Reducing Risks of Future Disasters,

Visman, E. (2016) Climate Information Services (CIS) for Improved Livelihood and Decision Making: A Practical Guide, Nairobi: Ada Consortium

Visman, E. (2016) The County Climate Information Services (CIS) Plan. Developing Decentralised, User-relevant Climate Information, Nairobi: Ada Consortium

WMO, GFCS: What are Weather/Climate Services? Retrieved on 01 November 2017, from http://www.wmo.int/gfcs/what_are_climate_weather_services.

WMO, GFCS: What are Weather/Climate Services? Retrieved on 01 November 2017, from http://www.wmo.int/gfcs/what_are_climate_weather_services.

World Meteorological Organization (WMO). 2014a. Health Exemplar to the User InterfacePlatform of the Global Framework for Climate Services.

World Meteorological Organization (WMO). 2014b. Agriculture and Food Security Exemplar to the User Interface Platform of the Global Framework for Climate Services

World Bank Group (2015): Increasing Agricultural Production and Resilience through Improved Agro-Meteorological Services. . Agriculture global practice technical assistance paper, 2015 World Bank Group, 1818 H Street NW, Washington, DC.

World Bank Group (2016): Climate Information Services Providers in Kenya. Agriculture global practice technical assistance paper, World Bank Group, Washington, DC.

World Water Council (2003). Camdessus, M. (ed). Report of the world panel on financing water infrastructure: Financing water for all.