SERVIR-Eastern and Southern Africa

Kenya Needs Assessment Report

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List of Acronyms

AGRA- Alliance for a Green Revolution Africa

ASARECA- Association for Strengthening Agricultural Research in Eastern and Central Africa

ASDSP- Agriculture Sector Development Support Program

AWF - African Wildlife foundation

CETRAD- Centre for Integrated Research in ASAL development

CIMMYT- International Maize and Wheat Improvement Centre

CORDIO- Coastal Oceans Research and Development

DEKUT- Dedan Kimathi University of Technology

DRSRS- Directorate of Resources Surveys and Remote Sensing

FAO- Food and Agricultural Organization

FTF- Feed the Future

GIZ- Deutsche Gesellschaft für Internationale Zusammenarbeit

GST- UON Department of Geospatial and Space Technologies

ICCA- Institute of Climate Change and Adaptation; University of Nairobi

ICIPE- International Centre of Insect Physiology and Ecology

ICPAC- IGAD Climate Prediction and Applications Center

ICPALD- IGAD Centre for Pastoral Areas and Livestock Development

ICRAF- World Agro Forestry Centre

IGGRS-DEKUT's Institute of Geomatics, GIS and Remote Sensing

JAICA- Japan International Cooperation Agency

JKUAT- Jomo Kenyatta University of Agriculture and Technology

JOOUST- Jaramogi Oginga Odinga University of Science and Technology

KARLO- Kenya Agricultural Research & Livestock Organization

KEFRI- Kenya Forestry Research Institute

KEPHIS- Kenya Plant Health Inspectorate Service

KFS- Kenya Forestry Service

KLIP- Kenya Livestock Insurance Programme

KMD- Kenya Meteorological Department

KNBS- Kenya National Bureau of Statistics

KNCPB- Kenya National Cereals and Produce Board

KU- Kenyatta University

KWS- Kenya Wildlife service

KWTA- Kenya Water Towers Agency

LECRD- Low Emission and Climate Resilient Development

LULC&E- Land Use, Land Cover Change & Ecosystems

MESA- Monitoring of Environment for Security in Africa

MoALF- Ministry of Agriculture, Livestock and Fisheries

NAAIP- National Accelerated Agriculture Inputs Programme

NASA- National Aeronautics and Space Administration

NCCRS- Kenya National Climate Change Response Strategy

NMK- National Museums of Kenya

PREPARED- Planning for Resilience in East Africa through Policy Adaptation, Research, and Economic Development

RCMRD- Regional Centre for Mapping of Resources for Development

SDC- Swiss Agency for Development and Cooperation

SGR- Strategic Grain Reserve

SHIP- Social and Hydrological Information Platform

SOK- Survey of Kenya

UNOSAT- United Nations Operational Satellite Applications Program

UON- University of Nairobi

USAID- United States Agency for International Development

WRMA- Water Resources Management Authority

WRSI- Water Requirements Satisfaction Index

EXECUTIVE SUMMARY

SERVIR E&SA has prioritized user engagements in the design and development of services in four service areas that include Land Cover Land use and Ecosystems, Agriculture and Food Security, Weather and Climate, and Water and Hydro-climatic Disasters to ensure that they address the needs of the stakeholders and users. In order to achieve this, SERVIR E&SA builds on the institutional partnerships and networks in Eastern and Southern Africa together with the network and partnerships associated with USAID country missions in the region.

SERVIR E&SA conducted needs assessments in Kenya to identify and understand existing and emerging needs in the use of Earth Observation and geospatial technologies in informing decision making in the four thematic areas. Key governmental, non-governmental agencies, private agencies, and research institutions were involved in these assessments. The assessments took the form of stakeholder presentations to understand the roles, achievements, challenges and existing initiatives that use or are potential users of geospatial technologies and also to understand decision-making contexts in addressing environmental management issues and how geo-information is used to inform decision-making processes.

Additionally, SERVIR-E&SA led the participants through a group exercise to identify at development problems related to climate change in each of the four service areas while also understanding the factors, both climatic and non-climatic, that contribute to these problems. This exercise identified various areas that could be improved relating to data and tools, data sharing and access, outreach, feedback and capacity development.

The participants highlighted land cover and land use changes, human-wildlife conflicts, and illegal trade in wildlife, invasive species spread, vulnerability of key sectors to the impact of climate change, water scarcity and accessibility, water quality monitoring, low crop productivity and food distribution, and finally low livestock productivity as serious climate-related development problems within Kenya.

There is an urgent need to address the challenges policymakers face in interpreting information coming from technical analysts as this impedes the use of information coming from EO and geospatial technologies to inform decisions and policy making. SERVIR E&SA is strategically placed to address this challenge leveraging from experiences within the diverse teams of experts within the project and its experiences working with partners dealing with policy making.

To improve existing efforts in addressing land use land cover change mapping, use of bulletins and web tools can be explored while existing portals could be linked to enhance data sharing and access. In addition, there is a need to develop metadata and improve quality assurance to enhance the usability of data by other

users. In regard to addressing the challenges in human-wildlife conflicts and illegal trade in wildlife, products and tools can be developed through participatory approach together with online platforms for data sharing. For the challenge of invasive species spread, there is a need to improve the capacity of stakeholders to process and analyze data.

Opportunities to address vulnerability to climate change in the country include using decision support tools such as VI that is available at the Centre, establishment of partnerships & protocols for data sharing, improving data management standards, developing specific tools and products for specific users, supporting curriculum development for climate change adaptation and working with existing forums to increase awareness of geospatial tools.

There are opportunities to improve existing efforts that are addressing water scarcity and accessibility which include developing National Spatial Data Infrastructure (NSDI), development of tools for a specific purpose and improving the capacity of stakeholders. In addition, for monitoring water quality, enhancing the use of mobile phone/apps for community feedback, use of the platforms like water information system (Majisys) to enable data integration and sharing, the creation of MOU between the different institutions to enable access/sharing of data.

Opportunities to address low crop productivity and food distribution include the development of data sharing platform, development of tools that meet the needs of different users, raising awareness of tools and products together with capacity building. Further, low livestock productivity can be improved through utilization of technology to enable livestock traceability, e.g. use of GPS enabled microchips, development of livestock disease occurrence and hotspot maps and breed suitability mapping.

The goal of monitoring and evaluation will be to measure the impact of key activities of SERVIR-E&SA which will include the establishment of partnerships, data sharing, development of tools and products, raising awareness to users and policy makers, utilization of tools and products to users and capacity building of stakeholders. The impact of these activities will be measured in terms of the extent they have be utilized in decision making for societal benefit. Tracking the users of these tools and products, how they used and decisions they make will be critical in this project. Timely geospatial data, Earth observations, and predictive tools and products are critical for effective decision-making for sustainable development.

1 BACKGROUND INFORMATION

SERVIR is a joint initiative of United States Agency for International Development (USAID) and National Aeronautics and Space Administration (NASA) to help developing countries improve environmental management and resilience to climate change by strengthening the capacity of governments and other key stakeholders to integrate Earth Observation information and geospatial technologies into development decision-making. SERVIR operates in a global network of hubs in Africa, Asia, and South America. The Regional Centre for Mapping of Resources for Development (RCMRD) hosts SERVIR Eastern & Southern Africa (E&SA) project.

The all-encompassing goal of the SERVIR-E&SA is to improve environmental management and resilience to climate change by strengthening the capacity of governments and other key stakeholders to integrate Earth observation information and geospatial technologies into development decision-making. Basing development decisions on better information in Eastern & Southern Africa help to achieve more resilient outcomes in the following thematic areas which are key to the region; agriculture, coastal zone management, disaster risk management, water resources, and land use.

The specific objectives of SERVIR-E&SA are to: improve the institutional capacity of RCMRD and plan for sustainability of SERVIR Eastern and Southern Africa, improve capacity to use information, improve awareness of and access to information, and to increase provision of user-tailored data and tools for decision-making.

To achieve these objectives and to ensure that user needs in the Eastern and Southern Africa region are addressed, SERVIR-E&SA organized two-day user needs assessment/stakeholder consultation workshop in Naivasha, Kenya, from August 2nd to 3rd, 2016 where governmental, non-governmental, academic, and private sector institutions participated. The total number of participants were 40 from 37 institutions. (See Figure 1 group photo and Annex B for participant list).

1.1 Objectives of the workshop.

The main objective of the needs assessment workshop was to engage with stakeholders from various institutions, understand the projects they are implementing and map out climate-related development problems, their needs and gaps inform of geospatial data availability and acquisition, data sharing challenges, geospatial tools used and capacity.

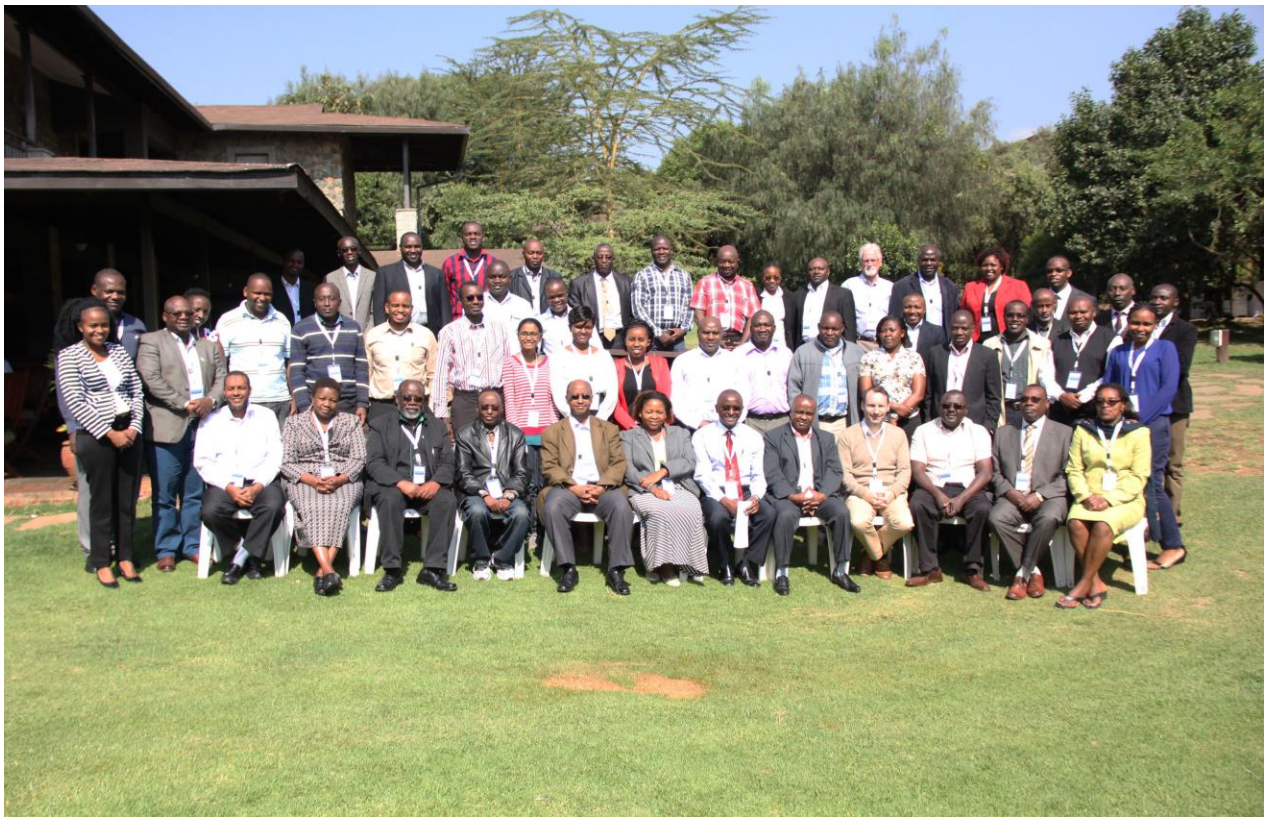

Figure 1: Workshop participants in Naivasha, Kenya

1.2 Methodology

A participatory approach was used in the workshop involving the formation of groups. The groups were formed based on SERVIR's four thematic service areas (i) Land Use, Land Cover Change & Ecosystems (LULC&E), (ii) Weather and Climate, (iii) Agriculture and Food Security, (iv) Water Resources and Hydro-climatic Disasters.

The workshop was organized into two stages; stage one (day one) comprised of stakeholder presentations where the stakeholders focused on showcasing their institutions' mandate/activities and achievements to create institutional activity awareness. In stage two (day two), in-depth development problem identification, scoping and analysis was done. This was through group discussions using a guiding questionnaire (see Annex D). The discussions concentrated on the following: (1) Identification of development problems, various institutions either directly or indirectly involved in the development problem, (2) Identification of factors (climatic and non-climatic) influencing the development problem, (3) decision-making related to the development problem identified, (4) identification of existing efforts towards the development problems, and (5) identification of potential opportunities which included user engagement, data sharing, access and management, capacity development, outreach, uptake and feedback.

2 INTRODUCTORY AND STAKEHOLDERS' PRESENTATIONS.

The opening remarks were made by representatives from RCMRD, DRSRS, and USAID Kenya & East Africa Region, after which an introduction and synopsis of SERVIR-E&SA project were presented by RCMRD.

The participants were then grouped into four groups in which presentations on their key activities, and challenges they experience in the implementation of their activities and decisions they undertake related to their mandates were made. The presentations are summarized below.

2.1 Land Use Land Cover and Ecosystems (LULC&E).

Twelve institutions participated in the land use land cover and ecosystems thematic service area. They include (1) Directorate of Resources Surveys and Remote Sensing(DRSRS) whose mandate is to conduct ground surveys, aerial surveys, remote sensing (land use land cover mapping) and Geo-information services in natural resources data analysis. (2) Kenya National Bureau of Statistics (KNBS) whose mandate is to conduct population and housing census and Kenya Integrated Household Budget Surveys (KIHBS). (3) Coastal Oceans Research and Development (CORDIO). CORDIO conducts water and water-related disasters assessment, coral bleaching and resilience monitoring, and ocean acidification and small-scale fisheries assessment. (4) Monitoring of Environment for Security in Africa (MESA) which conducts land degradation assessment and product bulletins, development of information monitoring system and deforestation statistics within IGAD region. (5) Kenya Forestry Service (KFS) whose activities include management of water catchments, climate change adaptation and mitigation assessment, conservation and protection of all public forests, and supporting community-based forestry enterprises in Kenya.

Kenya Wildlife service (KWS) (6), develops the ecological integrity composite index, carries out baseline survey, identifies ecosystem hotspots and reviews ecosystem management plans, rehabilitates degraded habitats, manages invasive species in Wildlife Protected Areas (WPAs) and finally identifies and maps wildlife corridors. (7) Kenya Forestry Research Institute (KEFRI) whose activities include long-term vegetation and environmental monitoring, forest valuation, development of pest and diseases management options, and also the development of rehabilitation techniques for degraded natural forests and woodlands. (8) Survey of Kenya (SOK) - activities include generation of rainfall and soil maps, land survey services, national park and reserves maps, topographic base maps and administrative maps production, land registration, and navigational route maps generation. (9) Jomo Kenyatta University of Agriculture and Technology (JKUAT) - activities include land resource planning and management, research and courses in biosystems and environmental engineering, and training and research in food science and technology. (10) National Museums of Kenya (NMK) develops biodiversity monitoring strategy for Lake Naivasha basin, strategic

environmental assessment for Tana delta, propagation of useful plants (medicinal), ecosystem service assessment and conducts pollination studies.(11) African Wildlife foundation (AWF) conducts activities related to protection of wetlands, afforestation, stabilization of land uses in areas surrounding protected areas, and promoting sustainable agriculture. (12) Nature Kenya focuses on important bird areas which host endemic globally threatened birds' species.

2.2 Weather and Climate

Six institutions participated in the weather and climate thematic service area. They include Department of Meteorology, University of Nairobi, IGAD Climate and Prediction Center (ICPAC), Kenya Meteorological Department (KMD), PREPARED project, Institute of Climate Change and Adaptation, University of Nairobi (ICCA), and Low Emission and Climate Resilient Development (LECRD) project.

Department of meteorology at the University of Nairobi provides quality education and training in meteorology, it's also involved in the development, exchange and exportation of innovative products. ICPAC collects weather and climate prediction data, conducts drought, flood monitoring, and generates information for regional early warning. KMD, on the other hand, organizes and administers surface and upper air meteorological observations, provides meteorological and climatological services to social economic sectors, issue timely warning on climate extremes, and conducts training and research. PREPARED builds resilience to address climate change and also builds capacity to cope with uncertainty, rather than reactive to specific climate impacts. ICCA activities include teaching, conducting action-oriented research, provide advice on national and regional policies on climate change. Activities for LECRD include strengthening of capacity for low carbon emission development in Kenya, building national institutional capacity to better coordinate climate change activities and finances, enhancing decision making to increase resilience to climate change and finally promoting smart technologies and business opportunities.

2.3 Water Resources and Hydro-climatic disasters

Ten institutions represented the Water Resources and Hydro-climatic Disasters service area. These are the Water Resources Management Authority (WRMA), Kenyatta University (KU), National Disaster Operations Centre (NDOC), Dedan Kimathi University of Technology (DEKUT), Egerton University, University of Nairobi (UON), Jaramogi Oginga Odinga University of Science and Technology (JOOUST), Kenya Water Towers Agency (KWTA), and the United Nations Operational Satellite Applications Program (UNOSAT).

WRMA's main activities are data provision on surface and groundwater, regulation, and allocation of water, water resources monitoring, integrated river basin management (IRBM)-community flood early warning

system, and on weather and climate, they do monitoring of weather elements like rainfall and ecosystems and environmental water regulation. WRMA is specifically involved in integrated river basin management in Nyando, Taveta, and Isiolo, mapping ground water resources and erosion hotspots and real time data collection using ODK among other activities.

KU, through a partnership with ESRI, has worked on integrated watershed management and soil erosion monitoring activities. The university is mandated to teach, conduct research and provide consultancy services. JOOUST through teaching, research and consultancies has worked on control of mosquito vectors and microbial pathogens, training on energy use and renewable energy, EWS, SDI for county governments, development of DSS for use by WRUAs, solid waste management in urban areas, water hyacinth making, urban planning, preservation and conservation of cultural heritage sites, fish cage culture (mapping suitable sites and breeding areas), and the flying food project (cricket rearing). The NDOC mainly coordinates disaster response activities and uses geospatial data to map hotspot areas. The center supports the reconstruction of infrastructure destroyed by disasters such as floods, sensitization of the public in case of a disaster through the media, oversees compensation payments for flood-related losses (e.g. death), and coordinates with Special Programs Department in the Ministry of Devolution and Planning for efficient provision of relief services.

The DEKUT's Institute of Geomatics, GIS and Remote Sensing (IGGRS) is involved in the implementation of a land administration domain in Kenya and the integration of GIS and remote sensing in EIA, e.g. the case of the mega-twin dam in Ewaso Nyiro basin. Egerton University is a partner in the MaMaSe water initiative, the EOIA project (WRMA in Naivasha), and ESA-TIGER. Other projects include the Mara-CGIAR project, within Nile basin ecosystem (It involves neighboring countries as well)

The UoN Department of Geospatial and Space Technologies (GST) has implemented activities cutting across all the SERVIR thematic areas. Some of the outstanding activities in the water sector include application of GIS in urban stormwater management, assessing the impact of climate change on food security in Turkana County, land use change in Thika, GIS-based multi-criteria analysis for irrigated agriculture, modeling hydro-power potential for Pekerra River, and dam design and construction in Samburu. The KWTA has been involved in physio-physical impact assessment for Mau catchment, rehabilitation of the Mau forest, development of ecosystem resource mobilization strategy, development of a livelihood handbook, and the real-time monitoring system for the southern Mau. The UNOSAT works with different institutions in capacity building in the use of the geospatial information, improvement of service delivery, rapid mapping in response to disasters, drought and flood hazard management, and management of live web map with ICPAC. UNOSAT has conducted 5 pieces of training in the application

of geospatial science, promoted high-level awareness raising in relation to disasters, has been engaged in El-Nino response, and uses a model called flood-FINDER for the whole of East Africa.

2.4 Agriculture and Food security

Seven organizations participated in the session representing the agriculture and food security thematic area. They include World Agro Forestry Centre (ICRAF), Centre for Integrated Research in ASAL Development (CETRAD), International Centre of Insect Physiology and Ecology (ICIPE), Wajir county's Department of Agriculture & Livestock, Ministry of Agriculture, Livestock and Fisheries (MoALF), IGAD Centre for Pastoral Areas and Livestock Development (ICPALD) and Kenya Agricultural Research & Livestock Organization (KARLO).

ICRAF works in six science domains implementing projects in agroforestry systems, products and markets, tree diversity domestication and delivery, land health decisions, environmental services and climate change vulnerability of smallholder farmers. The Wajir County Ministry of agriculture and livestock is focused on innovative, commercially-oriented, modern agriculture and rural development sector. CETRAD focuses on assessing and evaluating potential and utilization of resources in ASALs and understands the natural resources in their areas of operation. ICPALD promotes and facilitates regional policy frameworks in livestock and drylands development. ICIPE focuses on improving livelihoods, improving hive level productivity, and research on control of neglected tropical diseases. MoALF is mandated to achieving food security for the country through innovative, commercially oriented and modern agriculture. KARLO focuses on crops and livestock research in the country. They are mandated to generate technologies and outputs related to food crops.

2.5 Institutional challenges

Challenges faced by the institutions include geospatial data access and availability, inadequate skills, insufficient tools and models, inadequate hardware and application software, inadequate funding, limited methods in data and information dissemination, and lastly inadequate clearly defined user tailored products.

3 CLIMATE-RELATED DEVELOPMENT PROBLEMS

On day 2, the participants were grouped into the four SERVIR-E&SA thematic service areas namely land use land cover and ecosystem, weather and climate, water resources and hydroclimatic disasters, and finally agriculture and food security, (See Annex C for more detailed SERVIR-E&SA service areas and figure 2 for breakout session group on Land use land cover and ecosystem security service area). Development problems related to climate were discussed in the groups using a guiding questionnaire (see Annex D) and details highlighted below.

Figure 2: Land use land cover and ecosystem break out Session.

3.1 Land Use Land Cover and Ecosystems.

The LULC and Ecosystems discussion group identified land cover land use change mapping, invasive species spread, human-wildlife conflict and illegal trade in wildlife as major development problems.

3.1.1 Land cover land use change mapping

One of the major development problems in the area of LULC and Ecosystems was identified as land use change mapping. These conversions were identified to be the cause of land degradation, land fragmentation, encroachment on wildlife migration routes, riparian fringing, and loss of benthic cover.

Factors contributing to the problem, geospatial data, and stakeholders

Climatic factors contributing to the problem were identified as climate change and unpredictable weather fluctuations. Non-climatic factors contributing to the problem include conflicting policies, Lack of synergies/coordination by stakeholders, laxity in enforcement of policies, under- valuation of ecosystems. Anthropogenic factors such as uncontrolled land sub-divisions, infrastructure development, mining, charcoal burning, sedimentation, poverty, firewood extraction, over-exploitation of forest resources, population pressure and conversion of land use.

The geospatial data required to address the problem include: satellite images – medium to high resolution where high-resolution images have to be purchased but other medium and low-resolution images can be freely accessed; cadastral data/boundary data and fundamental data sets such as vegetation maps and topographic data can be obtained from the Survey of Kenya (SOK) at a fee; data on migratory routes/wildlife and livestock corridors can be obtained from institutions such as Department of Resource Surveys and Remote Sensing (DRSRS), Kenya Wildlife Service (KWS) and the Ministry of Agriculture, Livestock and Fisheries; population data from Kenya National Bureau of Statistics (KNBS); georeferenced/socio-economic data/cultural data from the KNBS, SEDAC and the World Bank; climate/ weather data can be obtained from the Kenya Meteorological Department (KMD) and IGAD Climate Prediction and Applications Centre (ICPAC); forest inventory data can be obtained from the Kenya Forest Service (KFS); biodiversity data from the National Museums of Kenya (NMK); and physical planning data that can be obtained from Ministry of Lands and Physical Planning.

Stakeholders affected by issues arising from land use land cover changes are all citizens, Government Departments, Civil Society and NGO's amongst others.

Decision-making Context

Decisions that are made related to land cover land use change mapping include the following: compensation of the issues of wildlife conflicts, policy formulation, forest zoning, the creation of water points, park planning, and land use plans, conservation management guidelines and infrastructure planning.

For these decisions the above decisions to be made information relating to population density, the intensity of degradation, carrying capacity of the land, change maps, effects of change of land use and the drivers of

land use land use change need to be well understood. Such decisions are made with reference to the Kenyan constitution, policies in place as well as enacted Acts of Parliament. Some of this information required is already being provided by institutions such as KWS, Government Agencies, KNBS and SOK amongst others.

User Capacities and Needs

The main users of the information on land cover land use change maps are decision makers, analysts who want to use the data either directly or integrate it with other data to create more information and at other levels. These users were identified to be stemming from government agencies, NGOs, international organizations, the private sector, researchers, resource users and managers and citizens of Kenya.

It was identified that albeit the efforts to make some of this information available by different data creators the information was not always available to all users or would be in formats that the users are not able to understand. Some institutions had no policy on data sharing but would be willing to share if there was a Memorandum of Understanding (MoU) and agreement but these cases were institution specific.

Lacking or insufficient skills/capacity to process and analyze data, access to software and hardware, platforms to inform decision-making processes were some of the issues identified to be affecting user uptake.

Existing Efforts

Some work has already been done by different institutions to address this problem some of the existing efforts include: System Land-based Emissions Estimation in Kenya (SLEEK) program supported by the Australian Government through the Clinton Foundation is developing 17 Land Cover maps for Kenya between the years 1990 and 2014; KWS and DRSRS have been over the years mapping wildlife corridors.

Additionally, DRSRS has developed comprehensive land use maps for three counties so far using aerial photographs and intend to cover all 47 counties in the coming future. Kenya Water Towers Agency (KWTA) has been involved in mapping the forests while Monitoring of Environment for Security in Africa (MESA) is also involved in developing land degradation maps for the entire IGAD countries as well as forest mapping of the major protected areas also in the IGAD region. Africa Conservation Centre, (ACC), has made efforts in developing the biodiversity atlas of Kenya, Kenya Forest Research Institute (KEFRI), KFS and KWTA have been involved in developing data on water resilience and Ministry of Planning developed the Kenya open data portal that allows access to several data sets developed by various willing parties.

Opportunities to improve

Among the areas that can be improved to address the LULC change mapping issue in Kenya are: use of bulletins and web tools have been encouraged to improve user engagements - it was recommended that existing portals should be linked to enhance data sharing and access; metadata creation and quality assurance to enhance usability of data by other users; data cataloguing would increase awareness of data available in different portals; use of Memoranda of Understanding; seminars and workshops as avenue to enhance awareness creation; identification of user needs; development of specific indicators and incorporation of international standards have been encouraged before development of products and tools. To enhance capacity development, training of the right people and regular training sessions have been encouraged as well as periodic updates of software and hardware to keep abreast with changing technology, bulletins, workshops, monitoring, and evaluation have been encouraged to promote outreach and user uptake.

Use of surveys to obtain user feedback was also encouraged. In addition, in order to improve better coordination of ongoing efforts, user group meetings, synergies, focus groups and joint implementation programmes are encouraged.

3.1.2 Human-Wildlife Conflicts and Illegal Trade on Wildlife

Human-wildlife conflict and illegal trade in wildlife is another development problem in the area of LULC and Ecosystems.

Factors contributing to the problem, geospatial data, and stakeholders

Climatic factors contributing to the problem were identified as climate and weather variations. Non-climatic factors contributing to the problem are fires, conflict on land use, infrastructure development /urbanization, land reclamation, uncertain land tenure, segmented policies.

The geospatial data required to address the problem are satellite images. These range from medium to high resolution and can be sourced from RCMRD and MESA while cadastral data/boundary, fundamental data sets data such as vegetation and topographic data is available from the Survey of Kenya (SOK). Migratory routes and maps on wildlife corridors can be sourced from DRSRS, KWS, and MOALF. Population data can be obtained from KNBS, SEDAC, and World Bank. Geo-referenced socio-economic data/cultural data can be sourced from KNBS. Climate data is sourced from Kenya Meteorology Department (KMD) and ICPAC. Forest inventory data can be sourced from KFS, KEFRI, KEMFRI, and KWS. Biodiversity data can be sourced from KWS, NMK, KFS, ACC, CORDIO, and MESA. Physical planning data can be sourced from Ministry of Planning. Conflict incidences mapping can be sourced from KWS and AWF.

There are a number of stakeholders that are already dealing with the problem including government institutions, land owners and communities.

Decision-making context

Various decisions made related to land use include the following compensation and awarding incentives, human capacity development, monitoring tools e.g. aerial surveys, capacity development of the staff and development of land use plans. In order to make decisions related to human-wildlife conflicts and illegal trade in wildlife, the following information is required: conflict hotspots, park and conservancies management plans, wildlife management plans, guidelines and national conservation and management strategy. Some of the information is available but there exist some gaps. This information also needs to be constantly updated.

User capacities and needs

The main users of the information on human-wildlife conflicts and illegal trade in wildlife are Land owners, County governments, Non-government organisations, NEMA as Clearing House, Beach Management Unit (BMU). There are some challenges in accessing the data such as gaps exist in data availability. Similarly, there is lack of data on community conservancies. Furthermore, there is also a challenge in affordability of necessary hardware and software and inadequacy of users' capacity to use the information to make more informed decisions.

Opportunities for improvement

There are various areas that can be improved to address the human-wildlife conflicts and illegal trade in wildlife. Engaging the main stakeholders such the KWS and the private sector institutions in the decision-making process is required. Initiatives in user engagement include: providing incentives so that the communities can protect wildlife, digital media campaigns so as to sensitise the communities on the importance of conserving wildlife, bilateral agreements such as the agreement with the Chinese government to control the sale of ivory abroad.

There is a need to collect conflict data and harmonize it using the help of citizens through interventions such as human web-sensor technology, short message service, etc. KWS provides data on human-wildlife conflicts and illegal trade on request. However, conditions are attached to sensitive data.

Implementation of data sharing agreements and online platforms would, therefore, alleviate the challenge on data sharing. Developing of products and tools can be improved through a participatory approach and engaging the citizens. Such initiatives include the use of SMART Tool, Wild, and Camera Traps.

Training on the development of geospatial applications was also identified as an area that could be improved as well as training of scouts and rangers on the use of modern tools and equipment and equipping them with skills to curb human-wildlife conflicts and illegal trade.

Additionally, there is need to improve outreach, uptake and feedback activities. This will include disseminating periodic bulletins, publications, and institutional web site organising sensitization workshops, incorporating monitoring and evaluation, using the social network to sensitise the citizen and conducting periodic surveys to get more information from citizens. Finally, there is a need to improve the coordination of on-going efforts through activities such as the creation of focused user groups meetings e.g. Conservation Alliance of Kenya, joint programmes, synergies, and expanding the scope of the stakeholders.

3.1.3 Invasive species spread

Kenya has had several invasions of alien species that have had negative impacts on biodiversity, agriculture and human development. For instance, prickly pear out-competes native plants preclude grazing and browsing near it and it regards the introduction of native species. Studies show that Kenya has been invaded by 34 species: 11 arthropods, ten microorganisms, nine plant species and four vertebrates. Management strategies have included quarantine measures for unintentional and intentional introductions, eradication, containment and control, monitoring and research, regional cooperation and public awareness. More cooperation, assistance and capacity building is required to effectively manage the problem of invasive species. Some of the most problematic invasive plant species identified by the stakeholders included Lantana *Lantana camara, Prosopis* spp., water hyacinth *Eichhornia crassipes, Pricly Pear* Opuntia spp., and *Prosopis juliflora.*

Factors contributing to the problem, geospatial data, and stakeholders

Climatic factors contributing to the problem were identified as prolonged droughts, tides, the wind, water and extreme weather variations. Non-climatic factors contributing to the problem include conflicting policies due to weak multi-sectorial coordination platforms, non-compliance and laxity in enforcement of regulations resulting in the introduction of unwanted species, insufficient research, and poor land tenure practices for instance land sub-division leading to sedentarization, (over-utilization of natural resources), resulting in degradation and spread of invasive species by livestock.

The geospatial data required to address the problem are the geo-referenced spatial extent of the invasive species, comprehensive inventory of all the invasive species, data on favorable ecological niches of the invasive species, land cover maps, and high-resolution images for mapping, modeling and validating the areas

prone to infestation. Several stakeholders are involved including government institutions, citizens, civil society, and NGOs.

Decision-making context

Decisions that are made related to the spread of invasive species include the following.

Quarantine measures to be taken during intentional introduction of alien species: the Intentional introduction of alien species in Kenya has been done under the authority of the Kenya Standing Technical Committee on Imports and Exports, which is a body that approves the importation of restricted and new materials into the country. The committee operates under the Plant Protection Act (Cap 324) of the laws of Kenya. Most of the deliberately introduced alien species are biocontrol agents. An appropriate risk analysis is carried out as part of the authorization process before coming to a decision on whether or not to authorize a proposed introduction. A comprehensive dossier on the intended introduction is submitted for evaluation by the standing technical committee. Authorization of an introduction is accompanied by conditions such as containment requirements, monitoring procedures, preparation of mitigation plans.

Eradication, containment, and control: For invasive species that have been unintentionally introduced to Kenya, appropriate steps such as eradication, containment, and control have been undertaken to mitigate adverse effects. For instance, for water hyacinth control, options have included mechanical removal of the weed and the use of bio-control agents. Monitoring is also carried out in other susceptible areas to detect invasion and hence put in place appropriate control measures.

Research and monitoring of alien invasive species: Much research has been undertaken in Kenya to develop an adequate knowledge base to address the problem of invasive species. This has been especially so for serious invasive species such as the water hyacinth and *Prosopis* spp. Research has been undertaken by national research institutes such as the Kenya Agricultural Research Institute and Kenya Forestry Research Institute. Studies have included the biology and ecology of the invasive species, history and ecology of invasion and associated impacts on the ecosystem, species, and socio-economic impacts.

Regional and international cooperation: There is a need for a regional approach to address the issue of invasive species because some of the species affect different countries. Examples include the water hyacinth, which has affected Kenya, Tanzania, and Uganda, and the larger grain borer, which has severely affected Kenya and Tanzania and hence it is vital to foster regional cooperation between the three East African states.

*Capacity building and public awareness***:** It is important to build the capacity of various institutions on identification and mapping of the invasive species and creates public awareness on the existence of various invasive species.

For these decisions related to the spread of invasive species to be realized the following information is important: international treaties regarding intentional introduction of invasive species, land use plans detailing the land tenure within specific regions and an invasive species inventory.

User capacities and needs

The main users of the information regarding the spread of invasive are the local communities, MOALF and KALRO. Not all users have software and hardware as well as platforms to inform the decision on the management of the invasive species and skills to process and analyse data are inadequate.

Existing efforts

The Kenya Plant Health Inspectorate Service (KEPHIS), as the national plant protection organization in Kenya, has worked closely with the research institutions (KWS, KEFRI, ICIPE, KFS, and NMK) to determine the status of invasive species and develop management options. Monitoring has also been done to detect new invasive species. Monitoring has involved institutions such as KARLO, the ICIPE, and KEPHIS. Monitoring has been carried out for species such as larger grain borer, fruit flies, and water hyacinth. Quarantine surveillance has also been done to detect new species.

On the international front, Kenya is a contracting party to the International Plant Protection Convention, whose purpose is to secure a common and effective action to prevent the spread and introduction of pests of plants and to promote appropriate measures for their control. With assistance from the Food and Agriculture Organization of the United Nations, training of staff has been undertaken to ensure awareness and increase knowledge on phytosanitary issues such as pest risk analysis and identification of pests of quarantine importance.

3.2 Weather and Climate

The identification of the development problem addressed below references the Kenya National Climate Change Response Strategy (NCCRS) and the objectives of 3 USAID-supported projects that participated in the needs assessment and addressing development issues related to climate change. Additionally, there were representatives from the University of Nairobi (UoN) Institute of Climate Change and Adaptation (ICCA) and the Department of Meteorology, together with representatives from the Kenya Meteorological Department (KMD) and the National Environmental Management Authority (NEMA) who are implementing climate change projects and supporting the implementation of the USAID projects.

3.2.1 Vulnerability of key sectors to the impacts of climate change

The vulnerability of key sectors to the impacts of climate change in Kenya has increased in the recent years and the consequences of these impacts to the sectors contributing to the national economy are already being observed and are projected to become more pronounced in the future according to NCCRS. For instance, the interaction of these climate change impacts with land degradation and deforestation in the Kenyan water towers (e.g. Mt. Elgon, the Mau complex, and the Cherangani hills) will have a negative impact on the environmental, ecological, social and economic value of these water towers ecosystems. The demand for energy is one of the main drivers of deforestation and land degradation. According to a report from the Ministry of Environment, in 2002, it was estimated biomass energy accounts for 78% of all energy consumed in Kenya. GHG concentrations in the atmosphere particularly those contributed by the AFOLU sector are projected to increase if the trend in deforestation and degradation in these critical ecosystems continues while the water levels in major rivers that originate from Kenya's main water towers will continue to decrease. There are emerging research questions in trying to understand how climate change exacerbates the loss of economic value of these water towers. Elsewhere, these impacts are also expected to affect the interaction between people and wildlife in critical terrestrial ecosystems/habitats (e.g. in the Mara-Serengeti region, the Northern rangelands and Tana delta, which is an important bird area.

Factors contributing to the problem, geospatial data, and stakeholders

Observed climate change is manifested in general decreasing trends in annual rainfall (recent decreases compared to 1960s) and more variable and declining rainfall in the 'long rains' (March-April-May). However, there are indications that the 'short rains' (October-November-December) are increasing and a tendency to extend into dry months of January and February in most areas. This latter observation has been partly attributed to the El Niño effect that is occasionally coupled with relatively warmer sea surface temperatures (SSTs) over the Western Indian Ocean and relatively cooler than average SSTs to the east of the Indian Ocean. Further, there is an indication of relatively more intense rainfall occurring more frequently over the coastal strip and the northern parts of the country in the September-October-November and December-January-February seasons.

Increasing trends in minimum (night/early morning) and maximum (daytime) temperatures has been observed over most inland areas, with steeper increases observed in minimum temperatures. This trend is projected to increase into the future while rainfall is projected to be more variable, with different patterns over most of the areas in Kenya. Extreme events (e.g. droughts and floods) are also projected to become more frequent, and more severe particularly in the 'worst' case Representative Concentration Pathway (RCP) scenario, RCP 8.5.

Non-climate factors that exacerbate this problem include: land use and land cover changes, poverty (dimensions related to GHG emissions vs human needs for energy, biomass, etc.), ecosystem changes and degradation, land degradation, land suitability (decreasing suitability and productivity of both agricultural and rangelands), proliferation of invasive species, reducing the range of available fodder for livestock and wildlife, conflicts (human-human and human-wildlife conflicts), pests and diseases (crops, livestock and human), access to safe water (livestock and domestic use), lack of good and reliable GHG inventories for different sectors e.g. waste and industries, governance (coordination and compliance at different administrative levels, e.g. national-county), access to data, information and tools that can address climate vulnerability and the predictability of climate change and weather. The interactions of these non-climate factors with the climate and global changes is poorly understood, particularly the credible quantification of how climate changes and variability interacts with the socio-economic dimensions in Kenya.

KMD is primarily responsible for collection, archiving, analysis and dissemination of weather and climate-related information to various stakeholders. The main climate data collected by KMD includes precipitation and temperature data through a national network of ground observing weather stations. Further, KMD carries out short-term and long-term weather forecasts and weather monitoring using various models such as Weather Research and Forecasting model (WRF). Various agencies have worked with KMD to improve their climate records, e.g. supplementing ground observations with data from earth-observing satellites and weather and climate data from regional models (e.g. CORDEX run by ICPAC). Historical climate datasets have also been derived by blending satellite estimates with station measurements, as is in the case of CHIRPS produced as a partnership between KMD, ICPAC, and UCSB/FEWSNET.

For various applications in research and development that address vulnerability issues related to the ecosystems identified above, the weather and climate data from the meteorological service is integrated with other environmental, biophysical and socio-economic datasets acquired from satellites data derived products such as land cover and land use from Landsat, and socio-economic surveys carried out byKNBS. Others include topography (DEM from satellite models such as SRTM), hydrological variables from models, livestock and wildlife population from aerial surveys carried out by DRSRS and KWS, soils (texture and quality) from ground measurements coupled with model simulations, land tenure from government sources (e.g. from Ministry of Lands) among others. RCMRD hosts an archive of most of these datasets that are acquired from partnerships with data providers from government, non-government, and private agencies.

Other stakeholders involved include: Kenya Forest Service (KFS), Water Resources Management Authority (WARMA), Climate change directorate, Kenya Forest Research Institute (KEFRI), County Met services, KALRO, County governments, Maasai Mara conservancies, Narok County, Maasai Mara university, Kenya Tourism Board, NEMA, National Disaster Operations Centre (NDOC), MOALF, Tanzania Wildlife

Research Institute (TAWIRI), and the Tanzania National Parks (TANAPA) both involved in trans-boundary conservation of the Mara-Serengeti ecosystem, CBOs and academic institutions.

Decision-making Context

To address the problems identified above, decision makers require information to make decisions such as: routine monitoring of water flows for early warning, catchment management, identification of suitable agriculture systems (suitable to water towers), identification of suitable areas for settlement, disaster preparedness and mitigation, ecosystem planning, identification and protection of wildlife corridors, infrastructure development and development of county spatial plans. This information is provided by various institutions listed above although while some are at an advanced level of efficiency in the provision of this information, there are challenges that they face in the execution of their mandates.

User Capacities and Needs

Various government agencies and ministries e.g. Ministries of Water, Environment and Natural Resources, MOALF, Ministry of Planning and Devolution, county governments, KFS and development partners are the main users of the information for making a variety of decisions as highlighted above. While it is believed many agencies in Kenya host important and useful data, access to this data and information derived from the data is often limited for many users. Bureaucratic challenges in accessing data from government agencies, for instance, make it difficult for users to use information to improve their decision making, while in other situations, it's the awareness of where to find the data that is lacking. With these challenges, it is further noted that while the technical capacity is fairly good at the mid-technical levels, decision makers lack the same kind of capacity making it difficult to improve informed decision making. In other cases, the hardware and software are expensive to purchase and maintain. This either affects the quality of data or the quality of information derived from products created from such data.

Existing Efforts

Currently, various efforts exist that are working on providing services related to the problem identified. These include: (1) USAID and EU funded projects e.g. USFS addressing issues in the water towers (USAID is supporting ICPAC and partners to carry out climate change vulnerability assessments and ecosystem services evaluation for 3 Water towers while EU is supporting work on 5 water towers. The EU project is addressing specific issues related to the development of county plans). (2) There is also another EU-funded 5-year project managed by a Norwegian technical university working in the Mara basin. (3) WWF is also working in the Mara to support county spatial planning. (4) Conservancies are implementing projects in the Mara basin e.g. the Mara Elephant project. (5) MAMASE - Mau Mara Serengeti project is another project

funded by the Dutch government. (5) The Nature Conservancy is supporting community-based livelihoods projects in the Mara. (6) DRSRS is carrying out land use land cover analysis with county governments and carrying out wildlife monitoring (aerial surveys) in the rangelands. (7)RCMRD is carrying out land cover land use mapping through the SLEEK project funded by the Clinton foundation.

Opportunities to improve

Some suggestions highlighted that could improve addressing the problem include: (1) Using decision support tools at RCMRD to foster user engagement- these tools include VI tool - applicable to 2 of the thematic areas identified above, and raising the awareness on the availability of the RCMRD Geoportal, etc. (2) There is a need for stakeholder mapping to reduce overlaps in some of these projects. (3) There is a need to align different current/ongoing complementary activities with ongoing projects such as the LECRD project working with county governments for awareness and capacity building. (4) Support data sharing initiatives, e.g. establishment of partnerships & protocols for data sharing (MoUs, data sharing agreements in the short term, e.g. between implementing partners and long term through establishing legal frameworks). Examples of these could be using existing RCMRD data sharing agreements to demonstrate the importance of data sharing e.g. with KMD, Survey of Kenya, DRSRS among others. (5) Improve data collection/acquisition and improving data management standards. (6) Provide open source data layers for existing and future initiatives. (7) Development of products and tools that are responsive to user needs. (8) Make tools and products user-friendly e.g. user-friendly interfaces through innovative mobile apps. (9) Support curriculum development for climate change adaptation, e.g. through the LECRD targeting planners at the county level and can use successful examples like GeoCLIM and VI tools to feed into the curriculum. (10) Use national and county forums (e.g. through a council of governors and mass media) to interact with users e.g. use of radio stations (Murang'a county met radio service). (11) Ensure sustainability of services provided to users.

3.3 Water Resources and Hydroclimatic disasters

Ten institutions were divided into two groups to help in identification of climate-related development problems in the thematic area. The approach taken by the group was to look at the water resources issues holistically and using the catchment/basin as the basic unit for water resources management. From that point of view, watershed/catchment degradation was felt to be one of the prominent problems. Once the catchment is degraded, issues on water availability/quantity, flooding, landslides and water quality among others arise. To be able to manage or solve these problems, there is need employ an integrated approach. The 2 major problems identified were water scarcity and accessibility, and water quality.

3.3.1 Water scarcity and accessibility

Water scarcity defined as lack of water for various users and accessibility as the ease in which the user can access water were seen in two contexts, (1) water being so much and (2) water being little. This problem was based on the second context. Water scarcity and accessibility is experienced in various basins within Kenya namely: (1) Lake Victoria basin (South Basin in Awach Kano and Mara, and North Basin in Marakwet and Moiben), (2) Ewaso Nyiro (North Basin in Maara, Wajir, and Isiolo and South basin in Suswa, Guruman, Magadi, around lake Natron), (3) Rift valley basin (within Molo catchment, Turkwel basin in Turkana) , (4) Athi River basin (in Kiboko, Makindu, Kajiado, Makueni**,** Voi, Kwale and Kilifi.), and (5) Tana Basin (in Tana Delta).

Factors contributing to the problem, geospatial data, and stakeholders

Various factors both climatic and non-climatic were found to influence water scarcity and accessibility in Kenya. The climatic factors included rainfall and temperature patterns/variabilities. High temperature leads to drying out of water resources as a result of an increase in evapotranspiration levels while low rainfall leads to lack of enough recharge on the water resources. Non-climatic factors contributing to scarcity include population increase which increases water demand, deforestation (leading to the inability of the catchment to retain water), algae bloom invasion, increased human activities like agriculture and unequal water distribution. Non-climatic factors for accessibility include lack of infrastructure, poor operations, and maintenance practices.

Geospatial data sets required and are currently being used to address the problem include rainfall data (spatial rainfall distribution data both from satellite Global Precipitation Measurement (GPM) and rainfall estimates and station data; (2) temperature. Rainfall and temperature are sourced from Kenya Meteorological Department (KMD), Water Resource and Management Authority (WRMA), NASA and NOAA. (3) Evapotranspiration data sourced from USGS; (4) river discharge data from WRMA; (5) Land cover data from DRSRS and RCMRD; (6) topographical maps from Survey of Kenya; (7) digital elevation models from DRSRS, USGS and JAXA; (8) soil data sourced from KENSOTA, FAO and KARI; (9) administrative boundaries from Survey of Kenya; (10) basin data up to sub-catchment level sourced from WRMA; (11) population data from KNBS; (12) deforestation data from KFS and KEFRI; (13) water use and levels sourced from WRMA and finally (14) infrastructure data e.g. DAM, water networks sourced from KENGEN, Water Service Boards and WRMA.

Various stakeholders are involved or affected by water scarcity and accessibility problem namely: Water Resource and Management Authority (WRMA), County governments, local communities (water users),

Water Service Boards (WSBs), National Environment Management Authority (NEMA), Ministry of Water, World Wildlife Funds (WWF), GIZ, Water service providers, Kenya Water Tower Agency (KWTA), Kenya Wildlife Service, (KWS), Africa Conservation Centre (ACC), and Centre for Training and Integrated Research in ASAL Development (CETRAD).

Decision-making context

Key decisions made relating to this problem are water distribution and sharing, water allocation plans, and infrastructural development. Water distribution and sharing and water allocation are done by WRMA as the guiding authority in collaboration with WRUAs. Infrastructural development decisions are made by WRMA in collaboration with other stakeholders namely County governments in various basins, NEMA, and development partners. In order to make the aforementioned decisions regarding water scarcity and accessibility, various information needed include water availability, water quantity, water supply, and finally water demand information. WRMA being the lead authority on water issues, is charged with the mandate of giving the aforementioned information.

User capacities and needs

The target information user (or users) to make decisions are WRMA, Water Resources Users Association (WRUA), WSBs, local communities and county governments. Users have access to necessary information at various levels. Raw data is available at a fee at WRMA while processed data is freely available to all the users. In addition, necessary hardware and software for information gathering and analysis are already in place in WRMA but not in other institutions, however, the skills to analyse the data at the lower units like the WRUAs is still lacking.

Existing efforts

On-going efforts in response to water scarcity and accessibility problem include: (1) over 500 WRUAs have already been formed (1500 more WRUAs expected to be formed), (2) development of sub-catchment management plans by WRMA, (3) WRMA is also in the process developing water allocation plans, (4) World Bank project on water security, (5) development of IGAD hydrological observation system, (6) capacity building of 11 WRUAs on watershed management by Africa Conservation Centre (ACC), (7) underground water mapping in Turkana and wetlands mapping for Kenya by DRSRS, and (8) delineation of WRUAs by CETRAD.

Opportunities to improve

Various aspects on how to improve tackling water scarcity and accessibility problem include (1) *User engagement*: There is the need to provide or develop a link to various institutions by creating an institutional network and training on more user-friendly software. (2) *Data sharing, access, and management*: Due to overlap or duplication of efforts there is the need to create a National Spatial Data Infrastructure (NSDI). The available data provided by various institutions has gaps and therefore the need to fill the gaps that exist. (3) *Developing products and tools*: The need to develop user specific tools for processing data into information and user-friendly packaging of the information. (4) *Capacity development – skills development/enhancement***:** Training curriculum should be designed based on the knowledge level of the user within various local communities. (5) *Outreach, uptake, and feedback***:** Much emphasis on water scarcity and accessibility efforts to be put print media**,** awareness workshops, training events, and customer and employee satisfaction surveys. (6) *Coordination of on-going efforts:* Various similar efforts are ongoing related to water scarcity and accessibility and this can be avoided by building a network to avoid duplication of this efforts. Many types of research focus on Mara and lower Nzoia and therefore the need to conduct research in other basins to increase knowledge and awareness.

3.3.2 Water quality monitoring

Water quality issues in the river basins are as a result of changes in the contributing catchments. The changes in the catchment mainly include deforestation/intensified land use change, soil erosion, population growth leading to intensification of the settlements in the catchment among others. The water quality issues affect both the rivers and the in-land lakes. Urban water is also being polluted due to poor waste management (waste coming from homes, industries, etc.). Pollution can be classified as point and non-point sources. Point sources include industrial waste and waste discharge from homes while non-point sources include soil erosion/siltation and nutrients discharges from farmlands.

Factors contributing to the problem, geospatial data, and stakeholders

The climatic factors contributing to the water quality problem are rainfall variability (low and high rainfall) which results to scenarios of high concentration of pollutants in rivers as a result of low rainfall and siltation in the rivers as a result of high rainfall. Low river discharges is also a main factor. The non-climatic factors include land degradation (soil erosion), population growth/intensity of the settlement, land use change, nutrients pollution from farm-lands, pollution which is brought about by solid waste management (urban and rural areas), industrial waste, oil spillage, air pollution from green-house gases and also topographical factors including the terrain and the underlying rocks. These factors contribute to both point and non-point pollution of rivers. The major contributing factors for non-point pollution alone include intensification

of land use and changes in farming practices which bring about soil erosion/ siltation, landslides among others.

To address the problem, various geospatial data were identified. They include topographical maps which come from the Survey of Kenya, soils data from Kenya Soils Survey done by KARLO or satellite-derived soil data from ISRIC and FAO, Digital Elevation Model (DEM) which is derived from satellite, land use/change maps from RCMRD, DRSRS or satellite-derived, geology data from the Ministry of Mining, climatic data (precipitation and temperature) which comes from KMD, satellite and other met stations from Egerton University, river discharges from WRMA, population data from KNBS, water quality monitoring points and parameters which is given by WRMA and finally the livestock statistics from DRSRS.

Various stakeholders are affected and involved with the main ones being the community who are always on the receiving end. Other stakeholders include the lead agencies named above who can either be data providers, implementers of activities or both. Other government agencies like NEMA, Ministry of Health (MOH) and MOALF - Department of Agriculture are involved in policy formulation.

Decision-making context

The data and information derived from these agencies are required for decision which includes formulation of pollution regulation policies, mitigation strategies, agricultural practices management, and identification of hotspots areas (sources and the causes of pollution). The type of information required for decision making includes sources of pollution, concentration/magnitude of the pollutants, who is being affected, spatial extent of where the pollution is happening, effects of the pollution, hotspots areas (in cases of erosion and intensified land use change), rainfall intensities and river discharge levels. The information for decision making is partially provided by the different agencies. WRMA provides information of the monitoring networks and the parameters and also the sources of pollution. However, this information is limited in terms of the parameters captured and the spatial coverage of the monitoring networks. WRMA provides this information in the form of reports and yearbook. WRMA also provides river discharge data. From the universities, research report and abstracts are provided. Water Service Providers (WSPs) provide information on water quality parameters especially for the drinking water while the community provides information of pollution incidences.

User capacities and needs

The users of the information above include agencies like WRMA, NEMA, WSPs, water companies, the private sector, MOALF, research institutes and also the professionals in some cases where they require baseline information. Some of the users do have access to the information while others do not. The

community has no access to the information. WRMA is mandated to carry out monitoring of the water quality and they provide the information in the form of reports. Raw data is not provided freely. There is, however, representation of WRMA in different regions and in cases of pollution e.g. from agricultural lands, they do liaise and share information with the relevant government agencies on the same. Some of the users like research institutes have the capacity to collect the data and process while institutions like WRMA have limited network (instruments) for monitoring water quality, limited labs for analysis and also limited skills.

The WRUAs in some specific catchment are trained to help in monitoring, but still, they have limited skills. This is because ongoing initiative within WRUAs are majorly on training. For some cases, some WRUAs are given incentives to help in monitoring and they are trained in using the monitoring kits, for example, the project under WWF and WRMA.

Existing efforts

There are various efforts that are ongoing and are related to the problem identified above. These are (1) WWF project – payment of ecosystem services (training of the WRUAs in using the water quality kit to monitor water quality for the Naivasha ecosystem, (2) Training of the WRUAs on the Open Data Kit in Naivasha ecosystem, (3) MaMase project which has a component of capacity building of the WRUAs in catchment management in the Mara Ecosystem, (4) Kenya Water Security and Climate Change program with the goal to enhance water security and also train the WRMA on catchment management, (5) putting up of automated stations under different initiatives like the MaMase, IGAD-HYCOS and Naivasha project, (6) KWTA project - has initiative going on focusing on the major water towers, and (7)Water Information System (Majisys) which was piloted in Naivasha and is now being up-scaled by WRMA to help them do water resources monitoring in the country.

Opportunities to improve

A number of opportunities to improve how the institutions respond to this problem were identified and these include involving the community in the monitoring exercises like the project in Naivasha, enhancing institutional communication which could be through forums, enhancing use of mobile phone apps for community feedback, use of the platforms like water information system (Majisys) to enable data integration and sharing, creation of MOU between the different institutions to enable access and sharing of data.

Under data, products development and capacity building, the stakeholders felt the need for enhancing the use of the developed tools like ODK and Majisys and training the WRMA, WRUAs and the community on the use of these tools, development of other user-friendly tools to monitor water pollution, collaboration to develop user-tailored products which could be using the available tools and other developed tools and

development of biological/ indigenous indicators for degraded water quality which can be easily understood by the community and help them on reporting back. WRMA is encouraging the formation of WRUAs to help in the management of these catchments in a holistic way but there is still need to empower the WRUAs to be able to perform this mandate which could be in the form of capacity building and development.

On outreach and uptake, the participants felt the need to enhance how the generated information reach the wider community and these could be through awareness creation to the community, research communication of findings to the community and putting the outputs from research and other studies in a way that is understood by the community, using the media to communicate the outputs and also getting the feedback and having feedback mechanisms embedded in some of the developed tools like Majisys.

3.4 Agriculture and Food security

In agriculture and food security service area, two development problems were identified by the participants. They are low crop productivity and food distribution and low livestock productivity.

3.4.1 Low crop productivity and food distribution

Agriculture in Kenya accounts for about a third of gross domestic product. Low crop productivity and distribution is a problem that is affecting the entire country in terms of food sufficiency. Distribution of food from the main growing areas to other areas is also a problem. 75% of the population are vulnerable to the low/poor crop productivity. In the ASAL region, food is not sufficient despite sometimes high production in "food basket" areas. The problem of low crop productivity was mainly attributed to low adoption of technologies such as conservation agriculture and rain water harvesting techniques and an over-reliance on rain-fed agriculture despite the high rainfall variability.

Factors contributing to the problem, geospatial data, and stakeholders

Droughts and floods, the unpredictability of rainfall due to changes in rainfall patterns caused by climate change and changing temperatures that lead to changing agro-ecological zones leading to changes in crop suitability and poor yields are some of the climatic factors contributing to the problem. Nonclimatic factors include pests and disease outbreaks, land degradation, changes in soil fertility which is further aggravated by the inappropriate use of inputs such as fertilizers, deforestation, population increase, declining farm sizes and low adoption of technologies. Poor marketing and distribution strategies for staple crops such as maize from areas of surplus to areas with shortages affect the market value chain.

The geospatial data being used to address the problem include weather alerts which are provided to the Ministry of Agriculture, Livestock and Fisheries (MoALF) by IGAD Climate Prediction and Applications Centre (ICPAC) and Kenya Meteorological Department (KMD). FEWSNET also provides MoALF with historical precipitation data. Some coarse crop suitability maps exist and are used by both MoALF and Kenya Agricultural and Livestock Research Organization (KALRO). However, detailed maps are required to inform decision making on crop suitability. Fertilizer suitability maps are available and updated under the National Accelerated Agriculture Inputs Programme (NAAIP) which is implemented by KARLO and MoALF. KARLO also provides a portal where fertilizer suitability information can be accessed. MoALF also receives outputs from the Water Requirements Satisfaction Index (WRSI) and NDVI from FEWSNET which they use for food security assessments. The Ministry also uses existing ecological zones maps which were updated for the main production areas and livelihood zones maps from FEWSNET.

Some of the stakeholders identified include government agencies such as MoALF at national and local level through the extension services, county governments, KARLO, farmers and farmer organizations, Kenya National Cereals and Produce Board (KNCPB) and Strategic Grain Reserve (SGR) secretariat which monitors food reserves, Kenya National Bureau of Statistics(KNBS), academic institutions and NGO's such as Food and Agricultural Organization (FAO), ICIPE, Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), Alliance for a Green Revolution Africa (AGRA), CETRAD, International Maize and Wheat Improvement Centre (CIMMYT), Japan International Cooperation Agency (JAICA), Feed the Future(FtF), Swiss Agency for Development and Cooperation (SDC) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

Decision-making context

Key decisions made concerning low crop productivity and distribution include strategies for crop production (crop selection), supply of inputs (seeds and fertilizers), selection of irrigation areas, early warning, disaster preparedness and response strategies, land management decisions, extension advisory and market, commodity value chain decisions, and trade policies such as disease control and import/export decisions.

Required information to make these decisions includes crop productivity, crop distribution, crop suitability, LULC and change maps, climate and seasonal weather information, market information, insurance information, crop losses and extent of damages in the event of hazards (flood, drought and pest and diseases occurrences), seasonal weather and crop forecasts and infrastructure information (roads, storage, warehousing and access to markets).

This information is required by national ministries (agriculture), NGOS, community and faith-based organizations, agricultural research organizations and KNCPB and SGR secretariat. At the local level government extension services and other local government operatives also require information.

Different users have varied access to the information. Government national ministries and SGR have access to information from KNCPB. Farmer and Farmer organizations receive weather alerts from MoALF who get it from KMD and ICPAC. Extension workers receive weather alerts, food security bulleting, early warning, markets information, fertilizer suitability and crop suitability information from MoALF. Development partners also require information for validation and tracking. NGOs, civil societies and agri-business owners and associations also require various types of information. There is inadequate information on disaster management (flood, drought, frost, wheat rust) especially quantification of the extent and number of people affected. Data on crop performance (at planting, at knee high, at flowering, at harvesting) is costly and harder to collect during the growing season. It is required to estimate extent/acreage and for monitoring. Data on trends in cropping patterns is also required as is historical land use changes and the effect on crop/food production.

User capacities and needs

Even where data is available the main problems faced are in the consistency and regularity of the data. Some of the data such as satellite imagery access are tied to cost. Updated software and hardware, skills and knowledge for processing and analysing available data are inadequate or sometimes lacking especially in government institutions. Sometimes, use of available information is hampered by a lack of understanding and interpretation skills of the data hence the need for refresher courses to assist in the interpretation of information and products and to provide updates on emerging technologies. There is a gap between information provision and packaging to suit different users such as technical staff, management and policy makers.

Existing efforts

Ongoing initiatives in response to low crop productivity include (1) Fertilizer suitability, early warning and crop insurance program by MoALF (however, they are using ground assessments and would require detailed information to inform crop insurance). The crop insurance project is being piloted in Embu, Nakuru, and Bungoma. The ministry is facing challenges in determining thresholds/conditions which warrant payment. (2) Wajir County conducted water and soil analysis in some areas to inform agricultural investments in the county. (3) KARLO has an online Agro-Weather portal that provides soil fertility and crop variety information. (4) Some surveys on market services & agribusiness have been done by KARLO and stakeholders through ASDSP (Agriculture Sector Development Support Program) which was done at

household and county level. Reports at the county level on households and markets sampled were recorded but not digitized. Information is being used to identify the priority value chains that inform decision-making at the county level. (5) CETRAD is also sharing data and published documents on a public website Social and Hydrological Information Platform (SHIP). They have also conducted training on conservation agriculture in Makueni, Kitui, Mwingi, Machakos and Laikipia. There is also a crop resilience project in Makueni.

Opportunities to improve

A number of opportunities for improvement exist namely, (1) the need to create a collaboration platform where all data and information producers and users can connect to share their outputs and where users can submit their needs. This will promote data sharing and improve access to available products and information. (2) Community-based programs should be promoted where local people can be trained on using new technologies and sensitization in better farming practices. (3)Developed tools and information should be tailored to meet the needs of different users. (4) The need for continuous awareness and capacity building on developed information, tools and products. (5) Creating awareness on existing models, projects and scalability requirements is also important. Some models have high data requirements that cannot be met and others use global or regional data. There is, therefore, a need to develop localized models for better assessments. (6) Promote collaboration and networking to enhance cooperation between institutions. (7) Need to streamline the information that is disseminated to users (international vs. national information) e.g. on early warning to reduce confusion. (8) Ensure that people who are trained pass on their knowledge to other colleagues or implement some project using the knowledge. (9) The trainer organizations need to put a monitoring and evaluation strategy to track post-training progress and impact. (10) In order to better coordinate ongoing efforts, there is a need for a regional agricultural forum to promote sharing, collaboration, establish linkages and allow understanding of all interested stakeholders.

3.4.2 Low livestock productivity

In Kenya, the rangelands cover 80% of the country and constitute the main livestock production areas. Livestock is the main source of livelihood in these Arid and Semi-Arid Lands (ASAL) and are affected by different climatic conditions and other factors. Livestock mobility makes it hard to contain and manage problems such as diseases and also accessing the animals for vaccination. This brings other cross-border problems such as tracking and controlling and managing the spread of diseases.

Factors contributing to the problem, geospatial data, and stakeholders

Droughts and floods, the unpredictability of rainfall due to changes in rainfall patterns caused by climate change and changing temperatures and water availability are some of the climatic factors contributing to the problem. Non-climatic factors include pests and disease outbreaks, land degradation, palatable forage availability, bush encroachment by invasive species, resource-based conflicts from wildlife, farmers and pastoralists as they complete for scarce resources, shift from cattle based systems to shoats (sheep and goats) and livestock distribution which might exceed the carrying capacity of the land.

The geospatial data available to address the problem include the Livestock Early Warning System (LEWS) from FAO and University of Texas and livestock census data from DRSRS. There is also an ongoing agriculture and livestock census from MOALF, seasonal migratory routes have been mapped by ICPALD for their northern Kenya clusters, FAO has mapped some migratory routes, CETRAD has mapped hotspots of water scarcity, NDMA has mapped water resources, County governments in livestock production areas and KARLO Marsabit has worked on breed suitability assessment. MoALF is also collaborating with the private sector such as ILRI and other stakeholders to provide livestock insurance through the Kenya Livestock Insurance Programme (KLIP). Livestock disease mapping information is required and ICIPE has conducted some mapping of Rift Valley Fever (RVF). Comprehensive forage assessments and mapping of viable grazing areas, ground water mapping and livestock traceability to support tracking of animal vaccinations, tracking the sale of animals in local and international markets and tracking stolen animals are some of the data required but not currently available.

Some of the stakeholders identified include government agencies such as MoALF at national and local level through the extension services, county governments, KARLO, livestock farmers and livestock farmers associations, meat, beef and hides traders, breeder organizations, veterinary service providers, academic institutions and NGO's such as NDMA, ICIPE, ILRI, CETRAD, ICPALD, Vétérinaires Sans Frontières (VSF), Mercy Corps, World Organization for Animal health (OIE) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

Decision-making context

Key decisions made concerning low livestock productivity include early warning and disaster preparedness and response, drought management, livestock census for planning, livestock traceability, disease control, disease free zoning, markets, government policies, cross-border trade policies concerning disease control and import/export, conflict resolution, veterinary services. The information required to make these decisions include climate and seasonal forecasts, infrastructure (roads, market information, abattoirs and

quarantine stations), livestock traceability, livestock forage maps and monitoring, disease monitoring, breed suitability, livestock disease and disease hotspots and groundwater maps.

This information is required by national ministries (agriculture), NGOS, community and faith-based organizations, agricultural research organizations, and the livestock breeders and traders. At the local level government extension services and other local and county government operatives also require the information.

Different users have varied access to the information. Government national ministries and county governments have access to livestock censuses, disease control and markets from ICPALD and other ongoing initiatives such as the Livestock Information Management System (LIMS), early warning and drought management information from NDMA. Livestock farmers and the county governments have access to livestock insurance and early warning information.

User capacities and needs

Consistency and regularity of the data is a major challenge while satellite imagery access is not readily affordable. Software, hardware, skills and knowledge for processing and analysing available data is not sufficient or sometimes lacking especially in government institutions. Use of available information is also hampered by limited understanding and interpretation of the data. There is a gap between information provision and packaging to suit different users such as technical staff and management and policy makers.

Existing efforts

Ongoing initiatives in response to low crop productivity include: LIMS, developed and maintained by ICPALD and MoALF; livestock censuses data conducted by MoALF; surveys on the overall economic contribution of the livestock to the GDP done by ICPALD; CETRAD data and documents on hotspots of water scarcity; NDMA has mapped water sources; FEWSNET has mapped markets and disseminates the information to MoALF; African Union Inter-African Bureau for Animal Resources (AU-IBAR) have established a disease database; Kenya Markets Trust and County governments are implementing holistic rangeland management but it is not automated; and NDMA provides some vegetation health indices using NDVI and other information for drought monitoring.

Opportunities to improve

In addition to the opportunities identified under the low crop productivity and distribution, there is a need for technology to enable livestock traceability, e.g. use of GPS enabled microchips, development of livestock disease occurrence and hotspot maps and breed suitability mapping.

4 WAY FORWARD

The user needs assessments in Kenya sets a foundation for user participation in identifying priority needs that will form the basis for future assistance to address those needs by SERVIR E&SA. Opportunities for SERVIR's contribution in existing and future efforts to improve environmental management and resilience to climate change were identified. SERVIR E&SA assistance will take the form of strengthening the capacity of governments and other key stakeholders to integrate Earth Observation information and geospatial technologies into development decision-making. With this in mind, there are potential areas of improvement that could be addressed through ongoing activities and other initiatives that SERVIR E&SA is participating in but prioritization of the needs through a 'value-addition approach' will be required. There is a need for further engagements/consultations with the relevant stakeholders in order to be able to design productive and effective services. This approach further will also address the issue of user buy-in, a result that would potentially increase the use of geospatial technologies in decision making in the Kenya.

Finally, the results of this assessment and of further engagements and consultations will form a core component of SERVIR E&SA's future work plans.

Annex A: Workshop Agendas

SERVIR EASTERN & SOUTHERN AFRICA (E&SA) - KENYA STAKEHOLDERS' AND CONSULTATIONS WORKSHOP

NAIVASHA KENYA, 02ND– 03RD AUGUST, 2016.

SERVIR is a joint initiative of United States Agency for International Development (USAID) and National Aeronautics and Space Administration (NASA) to help developing countries improve environmental management and resilience to climate change by strengthening the capacity of governments and other key stakeholders to integrate Earth Observation information and geospatial technologies into development decision-making. SERVIR operates in a global network of hubs in Africa, Asia, and South America. The Regional Centre for Mapping of Resources for Development (RCMRD) is one of the hubs in Africa.

RCMRD which hosts the SERVIR-Eastern and Southern Africa (E&SA) hub, is planning to convene a two (2) day workshop to assess the needs and gaps in using geospatial tools by various stakeholders including government agencies in Kenya.

The main goal of the workshop is to engage with stakeholders from various institutions, understand the climate-related activities they are implementing, map out problems or needs and gaps in form of geospatial data availability, acquisition, sharing, geospatial tools used and capacity required in processing data and using the tools.

Agenda

Day 1: Tuesday 02 August		
8:30 – 9:00	**Registration**	Stella/Lilian/Faith
	Introduction	Kasera
9:00 – 9:20	**Opening Remarks**: • Director Technical Services, RCMRD • USAID • Director General, RCMRD	 Kiema Chihenyo Farah
9:20 – 09:30	Introduction to SERVIR E&SA	Robinson
9:30 – 10:00	**Group Photo Session /Health break**	

STAKEHOLDERS' PRESENTATIONS				
Thematic Service Area: Water & Water Related Disasters (WRD) / Agriculture and Food Security (AFS)		**Facilitator: RCMRD**	**Thematic Service Area: Weather & Climate (WC) / Land-use, Land-cover & Ecosystems (LuLcE)**	**Facilitator: RCMRD**
10:00 – 12:30	Stakeholders Presentations		Stakeholders Presentations	
12:30 – 14:00	**Lunch**			
14:00 – 16:00	Thematic Service Area Groups Report Back			
16:00 – 16:15	**Health Break**			
16:00 – 17:00	Discussions/Questions			

Day 2: Wednesday 03 August		**Facilitator: Mubea**
08:45 – 09:00	Recaps/Day's Instructions	Anastasia
09:00 – 09:30	Service planning	Kasera
09:30 – 10:30	**Thematic breakout groups discussions:**	Facilitator
	I. Land-use/Land cover & Ecosystems	Edward
	II. Weather & Climate	Denis
	III. Agriculture & Food Security	Lilian
	IV. Water & Water Related Disasters	Faith
10:30 – 10:45	**Health Break**	
10:45 – 12:30	Groups Discussions (Contd.)	
12:30 – 14:00	**Lunch Break**	
	Group Report Back	
14:00 – 14:30	Weather & Climate	Denis
14:30 – 15:00	Water & Water Related Disasters	Faith
15:00 – 15:30	Agriculture & Food Security	Lilian
15:00 – 15:30	Land-use/Land cover & Ecosystems	Edward
16:00 – 16:30	NASA support to SERVIR	Ashutosh
16:30 – 16:40	Way forward	Robison
16.40 – 17:00	**Closing Remarks:** • Participant • Ministry of Mining/DRSRS • Remarks from USAID • Closing Remarks from RCMRD	One Participant Kenya's RCMRD Focal point, Chihenyo for USAID and Kiema for RCMRD

Annex B: List of Participants

No	Name	Organization	email
1	Mary Mwale	Ministry of agriculture, livestock and fisheries (MOALF)food security division	mary.mwale@yahoo.com
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Annex C: SERVIR Service Areas and Services

Food security

- Agricultural monitoring
- Drought management
- Crop productivity
- Rangeland decision support
- Aquaculture decision support

Weather and climate

- Weather monitoring and forecasting
- Climate modeling and scenario planning
- Air quality monitoring
- Adaptation planning

Water resources and disasters

- Water resources monitoring and forecasting
- Flood management
- Hazard monitoring and forecasting
- Fire monitoring
- Water quality monitoring

Land cover/land use and ecosystems

- Land cover/land use change mapping
- Ecosystem management
- REDD+ decision support
- Land use decision support
- Low emission development planning

Annex D: Break Out Questions

Needs assessment questions (Break-out Groups)

Identify a plenary presenter and plan approximately 20 minutes per question (120 minutes total)

1. **Problem Description and Stakeholders**
    a. What is the major development problem in this thematic area? (e.g., drought, flood, water availability, crop failure, pest outbreaks, land use change, etc.)
    b. What climatic factors contribute to the problem?
    c. Are there other non-climatic factors/issues that contribute to the problem? If yes, list them here.
    d. What geospatial data are required and/or are currently being used to address the problem above? And how do you acquire the data used?
    e. What stakeholders are affected and involved? (Including government, civil society, private sector)

2. **Decision-making Context**
    a. What are the key decisions related to this problem? (What decisions are getting affected by the problem)
    b. What information is needed to make these decisions?
    c. Is this information being provided? If so, by whom?

3. **User Capacities and Needs**

    a. Who is the target information user (or users) to make these decisions?
    b. Does the user have access to the necessary data or information?
    c. Does the user have the necessary hardware, software, and/or skills to use the information?

4. **Existing Efforts**
    a. What related activities are on-going in response to these needs?

5. **Opportunities to improve**
    a. What could be done to improve how you tackle the problems above in the following areas? (Consider feasibility of your options)

        i. User engagement
        ii. Data sharing, access and management
        iii. Developing Products and tools
        iv. Capacity development – skills development/enhancement
        v. Outreach, uptake and feedback
        vi. Coordination of on-going efforts